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Sky and TELESCOPE

Exhibit of ATM handiwork

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In This Issue:

Once in a Blue Moon

Eyes of the Astronomer

Cosmogonical Implications of the Atomic Bomb — V

Students, Double Stars, and the Future

Northern and Southern Star Charts

Sky and TELESCOPE

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In Focus

THIS month's back-cover picture adjoins the one reproduced last month, extending farther to the north on the moon (south is at the top). The crater Theophilus, which appears half on each plate, will serve to orient the pictures.

On the accompanying identification chart this month, as will be true of future charts, all named features on the moon are indicated. In comparing the chart with the picture, it will be noted that a number of good-sized features bear no names; these in most cases are identified by selenographers by the name of a nearby feature and a letter, with capital Roman letters serving for depressed features (craters, valleys, and so on), and small Greek letters for eminences.

Spellings used follow in all cases the official International Astronomical Union publication, **Named Lunar Formations,** by Blagg and Mueller. Bibliographical data given below are taken from the British Astronomical Association publication, **Who's Who in the Moon.**

Bellot. A small but distinct crater, very deep. Bellot, an arctic explorer and member of the French navy, has his place in the "navigators' corner" mentioned last month.

Capella. A 30-mile-wide ring plain, with very irregular walls. At the center is a massive mountain. This feature, with its astronomical designation, was actually named after a 5th-century lawyer and author.

Censorinus. A small crater almost lost in one of the brightest regions on the moon.

Da Vinci. A formation not fully enclosed, about 20 miles in diameter, is named for the famous Leonardo.

Dawes. William Rutter Dawes (1799-1868) was an amateur observer, independent discoverer of Saturn's dusky ring, and student of Mars and the sun.

Glaisher. James Glaisher (1809-1903), a pioneer of modern meteorology and founder of the Royal Meteorological Society.

Gutenberg. A large irregular ring plain, with eroded walls. Gutenberg E, a bay about 15 miles in diameter, adjoins it on the southwest. Johann Gutenberg was famous as the inventor of movable type.

Isidorus. An irregularly shaped enclosure adjoining Capella, but quite different in character. A six-mile crater is conspicuous in its interior.

Jansen. A ring plain which is about 12 miles in diameter, with dark interior and low walls. An optician, Jansen invented (by accident) the first compound microscope, and made a telescope so early that his son claimed he had priority over Lippershey in this respect.

Lick. Named for James Lick, founder of the California observatory, this is a crater about 20 miles in diameter.

Lyell. Sir Charles Lyell (1797-1875) was author of **Principles of Geology,** one of the fundamental works in the modern phase of this science. Named for him is a 25-mile formation, not fully enclosed, on the edge of Mare Tranquillitatis.

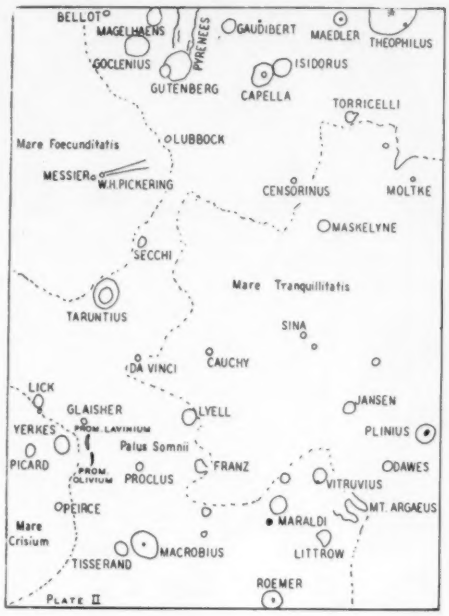
Maedler. A 17-mile crater with a central peak, named for one of the foremost students of the moon, Johann Heinrich Maedler (1794-1874), director of Dorpat Observatory for many years.

Magelhaens. In this 20-mile crater is commemorated a most famous member of the "navigators' corner," for this is the Portuguese form of the name Magellan.

Mare Crisium, Mare Foecunditatis, and **Mare Tranquillitatis** all appear on this month's map. The first is the Sea of Dangers. The second is the Sea of Plenty or the Sea of Fertility; largest sea in the western half of the moon, it embraces about 160,000 square miles. The Tranquil Sea is one of the darkest of the lunar maria.

Maskelyne. A formation which shows distinctly, surrounded by Mare Tranquillitatis. It is named for the fifth Astronomer Royal, who observed the transit of Venus at St. Helena in 1761, became especially interested in navigation, and was the founder of the British **Nautical Almanac.**

Messier. This small crater and the nearby W. H. Pickering (formerly known as Messier A but renamed by the Lunar Commission) have been suspected of change, as they have been observed to show apparent variations in size and appearance. Named for the famous comet observer and author of the Messier catalogue.



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BACK COVER: A portion of the west central region of the moon near first quarter, from a Lick Observatory photograph taken with the 36-inch refractor by J. H. Moore and J. F. Chappell. The reproduction is reduced 10 to 7 from a 7.8 enlargement of the original negative. (See In Focus.)

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ONCE IN A BLUE MOON

By J. Hugh Pruett

General Extension Division
University of Oregon

A rising moon, and a moon near quarter phase, are mentioned often in reporting observations of the blue moon. This photograph, by N. J. Schell, using a 10-inch off-axis reflector, shows our near neighbor several days past first quarter.

"ONCE in a blue moon" used to mean "never," and now it means "hardly ever." Such is the gist of a brief discussion given this mysterious expression by G. W. Stimpson in his book, *Nuggets of Knowledge.* But nothing in this particular nugget even remotely hints at a scientific explanation.

Literature on the subject appears to be practically nonexistent. At the University of Oregon library, I recently made a careful index inspection for the words "blue" and "moon" in all the many books on astronomy and meteorology, and in all copies of the *Monthly Weather Review,* published by the U. S. Weather Bureau, from 1898 to 1942. Not a single reference to "blue moon" was found in any of these. Thompson's *Meteorology,* published 95 years ago, mentioned a blue sun once seen in India, and stated that "it appears to depend upon the presence of vesicular vapor in the atmosphere, the different media of which produce upon light in its passage effects similar to those of mixed plates."

Also searched were Poole's *Index to Periodical Literature* (1802-1906), *International Index to Periodicals* (1920-1944), and the *Readers' Guide to Periodical Literature* (1890-1944). Every one of these big books had numerous references to scientific articles on the moon in a wide variety of magazines. One lone reference to "blue moon" was encountered: *Science,* December 28, 1934, page 617. This proved to be a description of an observation of this disputed phenomenon on September 15, 1934, by Perez Simmons at Santa Barbara, Cal.

Short discussions were published in The SKY, November, 1939, pages 17-18, and in *Sky and Telescope,* July, 1943, page 17, and October, 1943, page 9.

In his quiz column in the first *Sky and Telescope* reference above, Dr. L. J. Lafleur quotes an explanation found in the *Maine Farmers' Almanac* for 1937. In effect, this is that at one time the various full moons of the year were given names according to the order in which they occurred — provided there was only one per month. These names were as follows: Moon after Yule, Wolf Moon, Lenten Moon, Egg Moon, Milk Moon, Flower Moon, Hay Moon, Grain Moon, Fruit Moon, Harvest Moon, Hunters' Moon, and Moon before Yule. But seven times in 19 years there were — and still are — 13 full moons in a year. This gives 11 months with one full moon each and one with two. This second in a month, so I interpret it, was called Blue Moon, and was considered unlucky and a real nuisance as it occurred at various times of the year and upset scheduling of church festivals.

A hasty glance through the Canadian *Observer's Handbook* from 1936 to 1945 shows us that 1945 had no "blue moon," but that four times during these 10 years our lunar neighbor was at the full phase 13 times per year for observers in the Eastern time zone. Two per month occurred in September, 1936; July, 1939; April, 1942; and October, 1944. The second one in each pair was then a "blue moon." According to this, "once in a blue moon" means about once in two or three years, not an extremely rare occurrence. The next such "blue moon" will be on May 31st, this year.

But if the expression refers to a moon which actually appears blue in color, then for most of us this probably means once in a lifetime — or even longer. That such phenomena are sometimes, although rarely, observed, seems fully established by an abundance of witnesses. I had always been rather skeptical until the evening of July 28, 1944, when before my astonished eyes there hung in the southern sky a decidedly blue moon. Three of my neighbors were equally amazed by the very unusual sight.

The moon, at the first-quarter phase that day, was first noticed shortly after sunset, when it was thinly veiled by a small patch of high cirrus clouds, which were tinted a beautiful orange-red by the sun just below the horizon. We thought that the lunar blue might be the effect of contrast with the red of the clouds. But while we looked and wondered, the moon soon floated out into clear sky, and was just as blue as ever!

The blue was *not* uncertain and elusive, requiring close attention to discern the coloration. Not the least imagination was required. Normal eyes were impressed immediately with a very distinct blue so unnatural to the moon.

Now our readers must not picture old Luna grieving behind a dense veil of indigo blue. Nothing of the sort. All the features usually seen on the half disk were clearly visible, but the characteristic white of an early-twilight moon seemed to have been painted over with a very thin, transparent blue lacquer.

This blue was discernible for fully 15 minutes, but as the sky became dark-

er, the weird coloration gradually was lost in the yellow radiance of the night moon. In the *Science* article referred to above, Mr. Simmons states that the blue effect on the first-quarter moon was first noted eight minutes after sunset through a thin bank of cirrocumulus, begonia-rose in color. The sky was spectrum blue and the moon sky-blue. The colors were determined from a technical color chart.

Our observation was discussed shortly afterwards in my weekly astronomical column used by newspapers and radio stations in several far-western states. Accounts of previous observation by others were requested. Within two or three weeks a large number of "testimonials" had been received, some of which are given in part below.

When I read Harold Bell Wright's **Winning of Barbara Worth,** I thought his description of the blue moon was likely fiction. But later I too saw the same phenomenon in approximately the same place and probably under the same circumstances. One August day there was a high wind which filled the air with clouds of dust and sand. We could see the distant hills over the Mexican border with difficulty. About an hour before sunset, the moon quickly took on a bright, clear blue tinge and the air was filled with the same blue light. This lasted for only a few minutes. (Lester Ellis, Spokane, Wash.)

August 4, 1944, the sky became hazy and the moon had a distinct bluish tinge. This was the second time I had seen a blue moon. (F. O. Grams, Madison, Wis.)

I have twice seen a blue moon: in Venezuela in 1919 and in British Columbia in 1939. On both occasions it was midsummer and the blue appearance was as the light-blue side of the blue band of the spectrum. (John Hawthorne, Vancouver, B. C.)

Several months ago in the Aleutian Islands I observed a blue moon. It was a clear night in October or November, not late in the evening and the moon was about full. I wondered if it wasn't from volcanic action, blue dust in the sky. Several active volcanoes are in the vicinity, but I can't recall any disturbance at that time. (Pvt. Tadenoz Chumura, U. S. Army)

Last night I saw a strange sight. The moon was a pure greenish-blue and the sunset sky was green in places." (Pvt. W. G. Smith, in Italy, from a letter to his mother)

In 1928 some friends and I sailed the yacht **Red Riding Hood** from Falmouth, England, to Belize, British Honduras. When we were five days out of Bridgetown, Barbados, we saw a green moon. It was early April. Being interested in painting, I paid considerable attention in an effort to account for what I thought was surely an illusion in the physical sense but definitely a fact from the artist's point of view. The moon was a clear pastel green. The sun had just dipped below the horizon. The sky was cloudless and the atmosphere was extremely clear. The deepening blues of night were showing in the east but were not yet apparent in the vicinity of the moon.

The only explanation I could think of was that since the moon and sky "appeared" to be of equal values in terms of color (and consequently light), it might be possible to achieve under this condition some form of blending of the two colors resulting in green — which is no doubt physically impossible. (Hugh Clifford, Hollyburn, B. C.)

I have three times since 1936 seen blue moons. My sight is perfect and I am definitely very color-normal, as the Army physical examinations show. (Cpl. Armand Renaud, U. S. Army)

I observed a blue moon about 10 years ago. The moon was rising from behind the Cascade Mountains in front of which is a large mountain lake. It was very definitely blue. I figured it might be caused by the vapor over the lake. (Dr. H. L. Van Brodslin, Monroe, Wash.)

The occurrence was some 10 or 12 years ago when I was in charge of the U. S. Weather Bureau work in Yellowstone National Park. My impression is that when the blue effect was first noted, the moon was about 45 degrees high. There was at first a thin sheet of cloud over the sky, possibly cirrostratus. Later the clouds cleared away from the face of the moon and I had a clear-cut view. The sky carried a strong suggestion of blue, a pale, weird, steely blue. The time during which I was sure I was seeing a blue moon was probably around 45 minutes.

If I were going to try to dope it out now, I think that before going into any study of diffraction or diffusion, I would run over the possibilities of its having been a polarization phenomenon. I never did figure out any satisfactory explanation at the time, nor since. There was some discussion of this blue moon with friends — but just as little as I could manage. The "why" of the unusual is always asked, you know, entailing a response that in this case I was unprepared to give. I never did like to have to create a fog around something about which I was expected to know. (W. T. Lathrop, Meteorologist, U. S. Weather Bureau, Ret.)

Other correspondents at the time advanced various theories. Jeannette Townsley, of Seattle, wrote that she did not believe "once in a blue moon" referred to the moon at all, but to the mating season of certain deer in the Rocky Mountains. Once a year the deer take on a blue sheen called (first by the Indians) the blue moon.

R. C. Stroud, of Seattle, offered this: "Psychology reveals the afterimage to be the complementary color of any color which has strongly exercised the color perception center of the eye. The cones seem to reverse their process, and after staring at an orange sky for awhile the eyes would seem to see a blue cloud if they were turned on a white screen. The silvery moon acts as the white screen. The redder the sky, the more green would the afterimage be in complement. This accounts for the chap whose moon was more green than blue."

No explanation is offered here for a blue moon or a green moon. The evidence that such moons are sometimes seen is too strong to be treated lightly. Definitely, it is not an astronomical phenomenon but purely meteorological. Shouldn't the weather men go to work and give the rest of us a logical explanation to offer our interrogators so that we — and they — shall no longer have to "create a fog" around the subject?

The Demon Star

Ah! Algol! Your evil eye enchants me.
Evil—did I say? O, forgive me I pray
For there's nothing evil I can see.
What a pity that mythology narrate
You the Demon Star because of
Your remarkable coruscation which
Led to speculation that you
Must be evil and—
Then left you to that fate.
Perseus! Do you not resent it
Mythology should so present it?
Algol! From afar. Your very variation
Incites the imagination
To overwhelming admiration
For the so-called Demon Star.

MALLIE MAE KRAMER

New York Amateurs Aid Dutch Society

The Amateur Astronomers Association, which has its headquarters at the Hayden Planetarium in New York, is helping to replenish the library of the Netherlands Astronomical Society, located at the planetarium in The Hague, Holland. In addition to recent books on astronomy, magazine subscriptions have been taken out so that the members of the Dutch society may bring their sets of astronomical publications up to date.

There are unconfirmed reports that other groups in the United States have undertaken to replenish the depleted stocks of books at certain European observatories and astronomical institutions. Anyone wishing information concerning the needs of astronomers and amateurs in the various countries is invited to communicate with Dr. Bart J. Bok, chairman of the Committee for the Distribution of Astronomical Literature, Harvard Observatory, Cambridge 38, Mass.

National Capital Astronomers

On January 5th, the Washington, D.C., amateurs changed the name of their organization to the National Capital Astronomers. Previously, the society had been known as the National Capital Amateur Astronomers Association. At the same time, the society also adopted a constitution, and amended the by-laws. Junior membership was established with no minimum age; the initiation fee was abolished. Dues for regular members remain $3.00 a year.

Amateur Astronomers

Window Exhibit by Portland Amateurs

THE Amateur Telescope Makers of Portland, Ore., have had a publicity campaign to further an interest in observing and telescope making. The society believes that there must be quite a few people in its community who had never heard of the opportunity to join a telescope making group.

Part of the publicity plans included a window display in Gill's, a downtown store, which was tied in with books on astronomy and science, as shown on the front cover of this issue of *Sky and Telescope*. T. P. Maher, president of the A.T.M.'s of Portland, reports that the window display was so successful the store carried it for an extra week. The management of Gill's also suggested another window display of this kind later in the year.

About 15 letters from interested people were received, and the *Oregon Journal,* a daily newspaper, requested data for a feature article.

A copy of the president's report for 1945 to the society gives a review of the group's activities for the last of the war years. It includes an account of the eclipse trip which several members made to Wolseley, Sask.; it reports on the completion or work-in-progress of a number of telescope making activities, and describes group participation in photographing the Geminid shower and the lunar eclipse, both in December.

Arrangements have been made with several of the Portland high schools whereby the group will have up to five portable instruments available on certain nights for the use of high school students.

At the January 8th meeting, the 1945 officers were re-elected for another year. These are: president, T. P. Maher; vice-president, Howard Thomas; secretary-treasurer, Norman C. Smale. This was the 51st meeting of the association.

Building for Mexican Astronomical Society Under Construction

The latest issue of *El Universo,* bulletin of the Astronomical Society of Mexico, reports that work began recently on the building of the society which will be located in the garden of the Colonia Alamos of Mexico City. This marks the culmination of efforts by members of the society to have a headquarters building. Much credit is due Professor Luis Enrique Erro, director of the National Astrophysical Observatory at Tonanzintla, for having obtained from the government of the federal district the necessary means for the construction of the building.

Stellafane Meeting Announced

Amateur telescope makers everywhere will be glad to hear that the annual pilgrimage to Stellafane will get under way again this year. In the February issue of *Scientific American,* John W. Lovely, secretary of the Springfield Telescope Makers, 27 Pearl St., Springfield, Vt., is quoted as follows:

"We at Stellafane are planning to have a full-scale convention this year on Saturday and Sunday, August third and fourth."

It is expected that additional details will be announced later.

Detroit Astronomical Society

From the secretary of the Detroit Astronomical Society, we learn of the return of a number of its members to Detroit, some from overseas. She also reports that the club membership has more than doubled in the past year.

Officers elected at the January meeting of the society were: Dr. William Schultz, Jr., president; Dr. Ralph O. Fuerbringer, vice-president; George McCormick, treasurer; Margaret Back, secretary; William C. Nicholson, librarian; Cornelius W. Spain, director; Barbara Berry, social secretary; and Joseph Mazer, retiring president, with Dr. W. Carl Rufus and Dr. Robert R. McMath forming a planetarium committee.

THIS MONTH'S MEETINGS

Chicago: On Tuesday, March 12th, at 8:00 p.m., the Burnham Astronomical Society will hold a debate night, with three members on each side discussing the question, *"Resolved*: That animal life exists or has existed in the universe elsewhere than on the earth." The group meets at the Chicago Academy of Sciences Auditorium.

Cincinnati: Dr. Dale A. Wells, professor of physics at the University of Cincinnati, will speak on "The Basic Principles of Atomic Energy" at the March 8th meeting of the Cincinnati Astronomical Association, to be held at the Cincinnati Observatory at 8 o'clock.

Cleveland: "The Solar Spectrum" will be discussed by Dr. Charlotte M. Sitterly, Bureau of Standards, at the March 8th meeting of the Cleveland Astronomical Society, at the Warner and Swasey Observatory, 8:00 p.m.

Detroit: At 3 p.m., Sunday, March 10th, the Detroit Astronomical Society, meeting at Wayne University, will hear Claude B. Carpenter speak on "An Amateur's Experiences with Observatories, Telescopes, Celestial Photography, and Observing Conditions." Mr. Carpenter will illustrate his talk with original photographs.

Geneva, Ill.: Meeting at Aurora College, in Aurora, on March 19th at 8:00 p.m., the Fox Valley Astronomical Society will hear a lecture on "Meteorites: Objects of Great Human Interest." The speaker is Ben H. Wilson, of Joliet Junior College.

Indianapolis: On March 3rd, at 2:15 p.m., in Odeon Hall, the Indiana Astronomical Society will hear Dr. Daniel Layman speak on "The Stars of Spring."

Madison, Wis.: Following a discussion of Ursa Major, H. B. Porterfield will speak to the Madison Astronomical Society on "Wonders of the Sky." The meeting is at 8:00 p.m., at Washburn Observatory.

New York: "Geomagnetic Research" will be discussed by Dr. H. D. Harradon, of the Carnegie Institution of Washington, at the meeting of the Amateur Astronomers Association, March 6th, at 8 o'clock at the Roosevelt Memorial building, American Museum of Natural History.

Philadelphia: Dr. Jan Schilt, director of Rutherfurd Observatory of Columbia University, will discuss "Recent Trends in Astronomy" before the Rittenhouse Astronomical Society, on Wednesday, March 6th, at 8:15 p.m. This is the annual joint meeting of the Franklin Institute and the society.

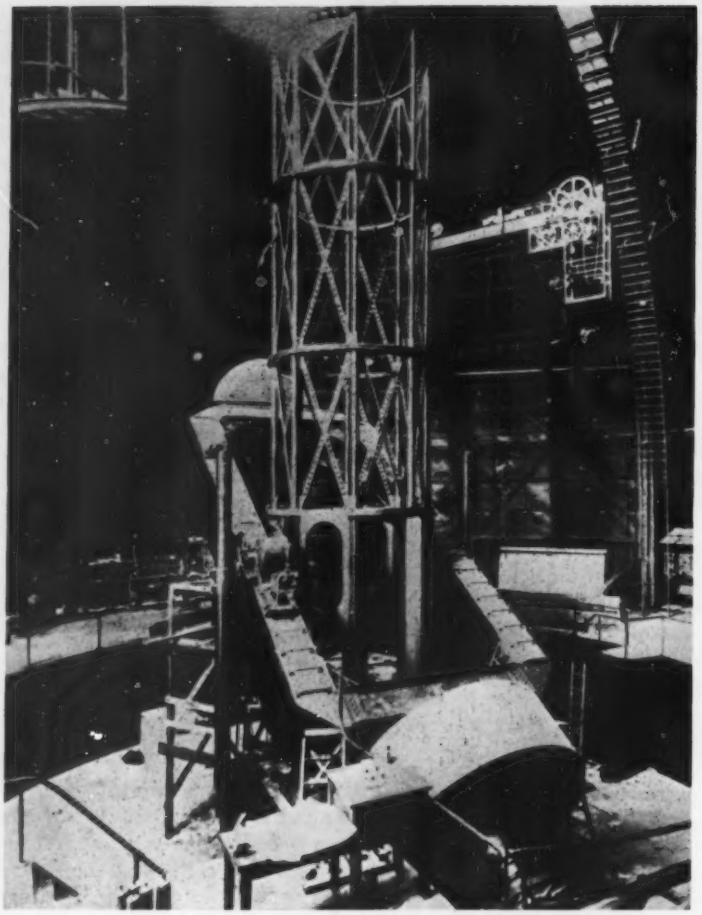
Pittsburgh: On March 8th, at the Buhl Planetarium, the Amateur Astronomers Association of Pittsburgh will witness a motion picture, "Eyes of Science," which shows in detail the methods of making lenses and mirrors. Commentary will be by Thomas LuCarric.

Washington, D. C.: The National Capital Astronomers will hear Dr. Allen Hynek speak on "What We Learn from Stellar Spectra," on March 2nd, at 8:00 p.m. in the National Museum. Dr. Hynek is at present with the Johns Hopkins Applied Physics Laboratory, Washington; he plans to return soon to Perkins Observatory of Ohio Wesleyan and Ohio State Universities.

Worcester: Before the Aldrich Astronomy Club, meeting at the Worcester Natural History Society on March 12th at 7:30 p.m., Dr. Charles H. Smiley, of Brown University, will speak on "Modern Methods of Navigation."

Eyes of the Astronomer

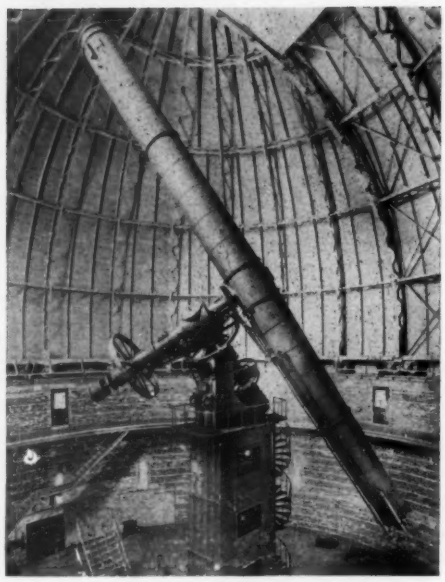
By Marian Lockwood
Hayden Planetarium



The world's largest operating telescopes of the two fundamental types are the 100-inch reflector at Mount Wilson Observatory, pictured at the left, and the 40-inch refractor of the Yerkes Observatory, shown below.

THE MIRACLE of light is always with us, and no matter how scientifically we may analyze its nature, we still bow before the wonder of its effulgence and the magic of the color which it paints upon the surface of the earth. The astronomer, not only as a man, but also in his official capacity, finds light the *sine qua non* without which he could not function, lacking which the celestial bodies would almost entirely escape his grasp. For astronomy has a rather special problem, peculiar to this particular science. Heavenly bodies, with the exception of meteorites, are not at hand and must be studied through the medium of light. It is only as we have learned to interpret the messages of light which come streaming to us across vast distances, from planets, comets, stars, nebulae, and galaxies, that we have become more intelligent about their nature. We cannot examine, dissect, and test these objects directly in the laboratory.

And so it is quite natural that a great deal of the ingenuity of astronomers has gone into the construction and refinement of instruments which will with increasing efficiency collect and gather, break up and analyze the rays of light which are our only visible connection with most of the heavenly bodies. In spite of these modern and highly specialized astronomical instruments, however, there is much which we still do not understand about the nature of light



itself. (See *Sky and Telescope,* August to October, 1945.)

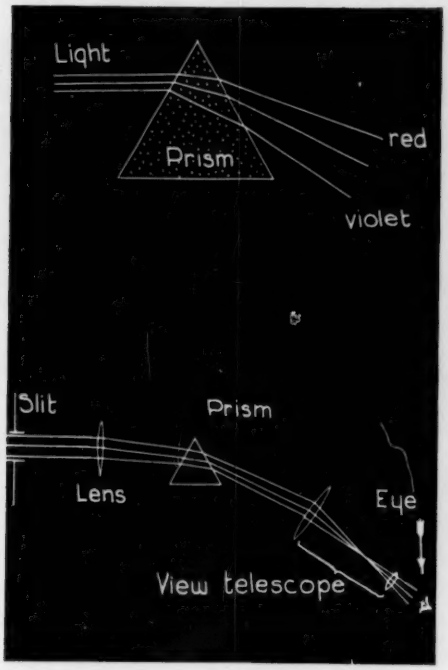
The first and most wonderful of all aids which the astronomer uses is his own eye, that surpassingly ingenious organism without which none of his work could be done. But the eye is limited in its power and efficiency. In 1609, Galileo Galilei, the Florentine astronomer, with excitement in his heart, gazed through the first telescope ever to be used astronomically. His little "optick tube," as he called it, made distant terrestrial objects appear larger, and increased beyond his fondest hopes his vision of celestial bodies. With his telescope, Galileo saw for the first time the four large moons of Jupiter, the rings of Saturn, and the mountains on the moon. And right there the modern phase of astronomical science began.

In observatories today, we find two basically different types of telescope, refractor and reflector. The refracting telescope, in its simplest form, is fitted with two lenses, the large, long-focus objective through which pass the rays of light from the stars, and the eyepiece, a short-focus lens mounted in a draw-tube which slides in and out so that the instrument may be focused to suit the eye of the observer. The reflector, instead of passing light through a lens, collects the light of a celestial body in a concave mirror, polished to a surface of near perfection. The light gathered by this primary mirror is reflected by a secondary mirror to an eyepiece in a convenient position. In the Newtonian type of reflector, the secondary is a small plane mirror placed at a 45-degree angle; it catches the rays of light just before they come to a focus and throws them to an eyepiece at the side of the tube. In another type, known as the Cassegrainian, a convex secondary mirror sends the rays of light directly back through a small hole in the center of the primary, behind which the eyepiece is located.

The refracting telescope has the advantage of possessing a wider field of good definition than the reflector, but the reflector is less expensive to construct and is completely achromatic, a great advantage in astronomical work. The average person imagines that the only duty of a telescope is to magnify an object. This is one of the important functions, but not necessarily even the primary one. The telescope does three main jobs: it collects the light of a celestial body and magnifies the image, revealing details which would otherwise be invisible; it collects and intensifies light so that objects too faint for naked-eye observation can be seen, and so that light can be transmitted to other instruments, such as the spectroscope, for study; it serves as a pointer to determine the positions of celestial bodies in any part of the sky.

With a photographic plate replacing the eyepiece, many telescopes are used as cameras; the largest instruments function almost entirely in this manner.

photographing remote parts of the sky and the spectra of stars, nebulae, galaxies, and members of the solar system. The 100-inch telescope can photograph stars as faint as the 21st magnitude and the 200-inch may reach to the 23rd magnitude. This means that at the present time, with the 100-inch, the visible universe as we see it from the earth has a diameter of about one billion light-years, meaning that our vision extends in all directions about 500 million light-years. When the 200-inch telescope is completed, perhaps next year, the diameter of the visible universe will be increased to about two billion light-years. What a far cry this is from the little optick tube of Galileo, through which he could see so indistinctly that the rings of Saturn, on an average about 900 million miles away, appeared like tiny ears or wings, strange appendages, so Galileo thought, to the lovely yellow planet!



The upper part of this diagram shows how a prism spreads light out into a spectrum. The principal parts of a prism spectroscope are shown in the lower part, with the path of the light rays indicated.

The largest refractor in the world is at Yerkes Observatory, in Williams Bay, Wis., boasting an objective 40 inches in diameter. The world's largest reflecting telescope is the Hooker 100-inch on Mt. Wilson at Pasadena, Cal. At the McDonald Observatory in Texas is the second largest reflector in the world, with a mirror 82 inches in diameter. Soon these will be completely outstripped by the gigantic 200-inch reflector to operate on Mt. Palomar near San Diego. Naturally, astronomers are waiting with great eagerness to see what this new instrument will tell them of the size and shape of the universe.

Now, if astronomers had only telescopes to work with, we would know very much less about the heavenly bodies, even counting the information gained by using the telescope as a camera. It is of the first importance to learn to decode the messages which light brings us across space, and for this purpose a spectroscope may be attached to the telescope.

We have known since the days of Newton that white light is made up of all the colors of the rainbow; the narrow band of many colors which is produced when light is passed through a prism is known as the visible spectrum. The spectroscope is a combination of prism (or grating) and view telescope. The light from a star (gathered by the large telescope to which the spectroscope is attached) enters a narrow slit, passes through a collimating lens which renders the rays parallel, and then passes through the prism or grating. The observer, with his eye at the eyepiece of the view telescope, then observes the spread-out band of many colors, each corresponding to particular wave lengths of light.

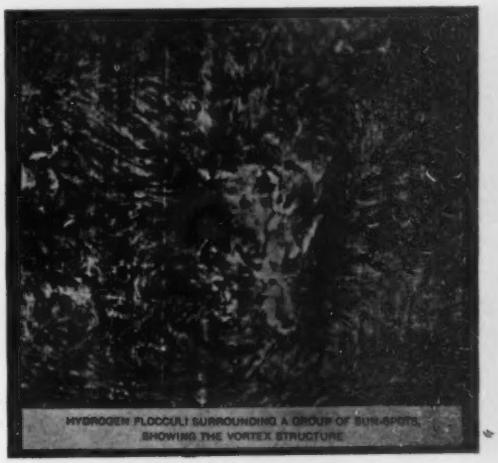
Each chemical element in the universe may be said to have its own distinctive fingerprints, for when the element is in incandescent gaseous form at not too high density, its light consists of a definite and unique pattern of lines, as seen in the spectroscope. The arrangements of these colored lines indicate without any possibility of mistake the presence of a definite element. Where compounds of several elements are concerned, bands are formed in the spectrum, each band containing a multitude of fine lines.

Thus, when we pass the light of a star through the spectroscope, we can tell by examination of the resultant spectrum that certain elements exist in the star itself, although not all those actually present may produce lines in the spectrum. This method is used not only for stars, but for the atmospheres of the planets, for the nebulae, and for other purposes.

The spectroscope and its various adaptations are the wonder-workers of the astronomer. How marvelous to be able to say without question that in the sun there are present at least 66 of the elements we know here on the earth, simply through the analysis of the solar spectrum. In addition to its use in analyzing the chemical constitution of the stars, however, the spectroscope helps us learn of the physical conditions under which their light is emitted. Further, by means of the Doppler effect, which changes the position of each line in accordance with relative motion in the line of sight between source and observer, we are able to complete our knowledge of the motions of the stars in space. We can discover double stars by this means, analyze the explosions of the novae, and make the observations which have led to the theory of the expanding universe.

A camera can be attached to the viewing end of the spectroscope, and in this case the instrument is called a spectrograph, which produces photographs of the spectrum to be studied at leisure. The spectroheliograph is a modification of the spectroscope, invented in 1890 by Hale and Deslandres, independently, by which the various aspects of the sun's surface and atmosphere may be photographed in the light of various single elements. In more recent times, the coronagraph, invented by Lyot, has been used for the same purpose. A spectrohelioscope enables visual observations to be made after the manner in which photographs are taken with the spectroheliograph.

Other adjuncts to the telescope are the interferometer, for measuring the apparent diameters of the largest stars and the separations of very close double stars; the thermocouple, with which the temperatures of the stars and planets may be measured; the objective prism, which produces spectra of large numbers of stars simultaneously; and various gratings, filters, sectors, used for special purposes. The Schmidt-type telescope is essentially a reflector with a spherical primary mirror, but its correcting plate might be considered by some to be a lens. The Schmidt has an unusually large field of almost perfect definition, and is a very popular instrument among astronomers today.



One of the special instruments which astronomers employ is a spectroheliograph, with which photographs of the sun in the light of one line of the spectrum can be made. Above is a spectroheliogram made with the red hydrogen alpha line, revealing the whirling clouds of hydrogen in the sun's atmosphere.

It is entirely possible that with the advent of new electronic methods quite different types of telescopes may be in the offing. In any case, amazing advances should come within the next few decades, for this is literally the wonder age of science.

COSMOGONICAL IMPLICATIONS OF THE ATOMIC BOMB--V

BY FELIX CERNUSCHI, *Guggenheim Fellow at Harvard University*

12. A new theory of the origin of the chemical elements

GENERALLY it is supposed among physicists that a neutron core would represent the most stable state of matter, but this is probably not so. The emission of electrons by some radioactive elements — the process of beta-decay — is interpreted as the transformation of a neutron into a proton in the nucleus of the corresponding element. Consequently, for the density of neutrons as high as that in the nuclei, and for absolute temperatures not much higher than 10^7 degrees, a high percentage of neutrons ought to be transformed into protons with the emission of electrons. Also, we know that the number of isotopes of any element is limited, which means that it is not possible to pack in the same chemical element as many neutrons as we would like. This observational evidence favors our fundamental hypothesis.

These facts can be explained if we assume that the binding energy between one proton and one neutron is a little higher than the binding energy between two protons. At the density of matter in the nuclei, therefore, the neutrons will build up into neutron-proton pairs, because that would produce a lower potential energy of the system and a more stable transitory state. From this, we might expect all the elements to have equal numbers of protons and neutrons; this is roughly the case with the lighter elements. Inside the nuclei of the heaviest elements, the Coulomb repulsive forces may not be completely destroyed; this would produce the transformation of less than 50 per cent of the neutrons into protons in the heavy or superheavy elements to which we shall refer later. From the fact that a helium nucleus has a greater binding energy per particle than the deuteron (heavy hydrogen), we may infer that two protons and two neutrons form a very stable unit, and, consequently, that the attractive forces between pairs of particles are not completely saturated within each pair.

During the cooling process of a primitive star built up of neutrons only, the decrease in central temperature would result in an increase in the neutron density. When this equals the density of matter in atomic nuclei, of the order of 10^{14} grams per cubic centimeter, our previous considerations indicate that the neutrons would be no longer stable and that a considerable percentage of them would be transformed into protons with the emission of electrons. It is quite reasonable to assume that when the density of neutrons tends to be greater than the density of matter in atomic nuclei, the attractive force between nearest pairs will be transformed into repulsive force, due to the finite dimensions of the neutron. This will prevent the collapse of the neutron core by reducing the central temperature until it reaches a value of about 10^7 degrees, corresponding to the temperature of the particles inside the atomic nuclei. Here we have the circumstances required to build up all the chemical elements.

Previous theories on atom building have always had the problem of electrical repulsive forces between positively charged particles, making it necessary to give an extremely high velocity to protons to enable them to go inside a nucleus to form another nucleus of higher atomic number. Although this does occur in the carbon cycle, where protons build as high as (unstable) oxygen at temperatures prevailing inside the sun, such extremely high temperatures and pressures are needed for the heavy elements that any possible star would explode before having time to build them. Laboratory experiments show that most cases of bombarding one nucleus with another provoke a nuclear reaction or a fission, and not a stable compound nucleus.

These difficulties are overcome with our proposal, because the protons appear under just the right conditions and at the right distance from other protons and neutrons to build up all the possible nuclei. In this way, we do not have to surmount the repulsive forces between light and heavy nuclei to bring them together to build up the heaviest nuclei. Neutron core stars, therefore, afford a simple explanation for the origin of the chemical elements. Previous theories of element building have pictured a gas of various nuclei in equilibrium with protons and neutrons, but since we know now that neutrons under such conditions will produce fission, such equilibrium cannot exist. From our theory the existing chemical elements would be the result of the radioactivity and fission processes from the original unstable super-elements. The distribution of the elements would depend on the corresponding packing fractions and the effective temperature inside the super-nuclei.

Although a neutron has no electrostatic charge, it has been found experimentally to possess a magnetic moment. This sounds rather mysterious, and it is, for nothing is really known regarding the structure of the fundamental particles. Any picture we might attempt to draw of the neutron is probably wrong, but let us imagine how a neutron might have a magnetic moment and yet appear electrostatically neutral. Suppose it were made up of a positively charged central part surrounded by a rotating shell of negative electricity. At not very small distances from the particle, the positive and negative charges would neutralize each other; yet the magnetic moment would result from the rotation of the shell of negative electricity.

This very provisional model might also explain the transformation of neutrons into protons by the production of electron-positron pairs. The positron would neutralize the exterior negative charge in each case, and the liberation of energy thereby would be equal to the difference in mass between the neutron and the proton. The formation of such pairs in the interior of a neutron core star could be due, for instance, to inelastic collisions between neutrons, a million electron volts of energy being required to produce each pair. If the energy taken from the non-elastic collision were greater than this, the difference would accelerate the electron and positron produced, or produce excited states of these particles according to what we suggested previously in these articles.*

All this mechanism may not be correct, of course, but our fundamental considerations are quite independent of any concrete model representing the neutron. In general, from the present state of the quantum theory, the proton and the neutron can be considered as two different states of the same fundamental particle (just as the mesotron and the electron may be). In a neutron core, the probability of transition of a neutron into a proton increases rapidly from near zero to a finite value less than one half, when the neutron core reaches the already specified physical conditions. Let us see how these proposals may explain diverse facts in a coherent way, and may therefore be taken as useful working assumptions for the time being.

*The recent announcement by General Electric of the artificial production of mesotrons of different masses by means of the 100-million-volt betatron adds further justification to our assumption that electrons and positrons ought to have an internal structure which enables them to reach excited states. The observed mesotrons would be excited states of electrons and positrons.

13. Novae and supernovae

THE SUPERNOVAE, according to W. Baade and F. Zwicky,[36] are stars whose visible radiation at maximum is of the order of 6.3×10^7 times that of the sun; a supernova may shine, then, at the rate of 2.38×10^{41} ergs per second, which is roughly equivalent to a transformation of 10^{-11} to 10^{-12} of the total mass of the star into energy every second.

At their maximum light, supernovae range between absolute magnitude —12 and —16. From existing observational data, it seems certain that supernovae are stars in an explosive state and that they eject stellar material at great velocities. F. L. Whipple and C. Payne-Gaposchkin[37] have given a satisfactory theory of the observed changes in the spectra of supernovae, and Whipple[38] has listed the following characteristics for certain of these stars:

Galaxy NGC	*Vel. of expansion km. per sec.*	*Maximum abs. mag.*	*Visual energy in ergs*
1003	6,000 to 7,000	—14.0	6×10^{47}
4273	6,000 to 7,000	—12.4	2×10^{47}
4303	5,800	—11.9	
I4182	4,500 to 6,000	—16.2	4×10^{48}
5253	5,000	—17 (?)	

There exists a great difference between the maximum luminosities of novae and supernovae. The former attain average absolute magnitudes at maximum of about —3, and matter expands around them at velocities ranging from 800 to 2,300 kilometers per second. These two types of stars appear to represent different kinds of stellar explosions, but Whipple has pointed out that there probably exist fainter supernovae bridging the gap. Our proposal is that neutron cores of different sizes furnish different amounts of "explosive" material.

A supernova must emit particles of very high energy. To deduce the ratio of visible radiation to the total energy output (radiation plus emission of particles), it is necessary to know the concrete mechanism of energy production in a supernova. Theoretical considerations from thermodynamic relations deduced for pure radiation at equilibrium are completely inapplicable in the case of a stellar explosion with the emission of particles. Baade and Zwicky, in another paper,[39] suggest that a supernova represents the transition of an ordinary star into a neutron star, consisting mainly of neutrons.

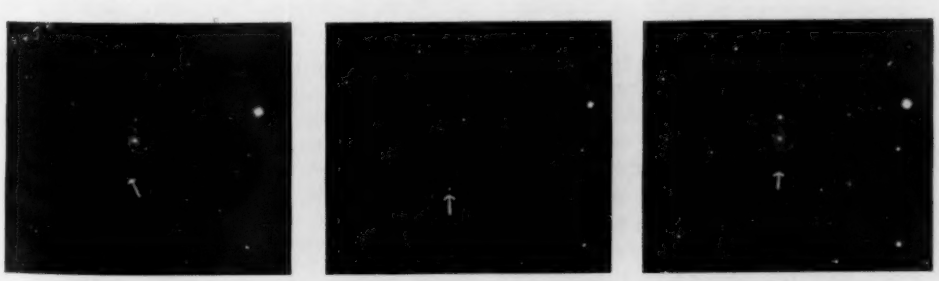
But Landau has pointed out (see last month's discussion of his theory of stellar energy production) that unless a neutron core of 1/20 of a solar mass already exists in a star, it is not possible to expect transformation of matter into neutrons. Furthermore, even if the neutron core already has a mass greater than this value, the transformation of nuclei into neutrons would produce energy which would, in turn, increase the temperature and decrease the density of the neutron core. There would result a reduction in the gain of gravitational energy per gram of matter transformed, an effect which would reduce the rate of reaction of the process, instead of increasing it, as would be necessary in Baade and Zwicky's theory. Consequently, if a neutron core could be formed at all in that way, its formation would never produce an explosion, but a steady emission of radiation according to Landau's theory. Besides, his theory, which for other reasons seems not correct as we have pointed out previously, would require a mechanism of credit of energy, which is very difficult to admit in physical theories.

To explain a stellar explosion, we need a definite chain type of reaction, or a nearly simultaneous transformation and reaction. In a chain reaction, the completion of one cycle of the process increases the probability of its repetition. If such a reaction inside a star is not energetic enough to produce a total dissipation of matter, the star may set up an alternate contraction and expansion, after the manner of Cepheid variable stars. But if the chain reaction is very fast and energetic, the star may explode with more or less intensity, accounting for the supernovae and the novae.

Only chain reactions similar to the type used in the atomic bomb appear capable of releasing the great amounts of energy in the relatively short time required in the novae. The reactions known at present take place between neutrons and the heaviest elements, including neptunium and plutonium. We have already indicated the possibility of the formation of such heavy elements in the interiors of neutron core stars, together with the rest of the elements. Superheavy elements of atomic number greater than 92 would, in general, have a very short mean life, and under the bombardment of neutrons they would disrupt into two or more nuclei. Each such process would yield more neutrons to carry the process further just as in the atomic bomb. With this mechanism, it is possible to have the complete explosion of a star,[40] although the rapid liberation of the energy of a supernova would probably prevent its complete destruction.

To explain the difference between novae and supernovae, we might suppose that the supernova, before explosion, is a star with a thin atmosphere and a large neutron core. After the explosive period, the "remains" of the star would drop to a quasi-equilibrium state with a thick atmosphere and a poorer neutron core. There would still be further explosions, by the same mechanism, which would appear to us as those of ordinary novae.

These briefly sketched proposals are sufficient to show that our assumptions about the processes inside neutron cores give plenty of room for theoretical speculation concerning the evolution of stellar matter. Technical discussion of these possibilities will appear elsewhere.



Three supernovae which appeared in the same spiral galaxy, NGC 3184. From left to right, they were photographed in December, 1937, and in December and April, 1921.

14. The origin of cosmic rays

THEORIES attempting to explain the origin of cosmic rays must all take into account the very high energy with which this radiation enters the earth's atmosphere. R. A. Millikan[41] supposes that cosmic rays originate in interstellar space due to the annihilation of matter. The average density of interstellar matter is of the order of 10^{-24} grams per cubic centimeter; the temperature of the gas particles about 10,000°, and of solid particles about 3° above absolute zero. It is difficult to see how these conditions would favor the destruction of matter in interstellar space.

Furthermore, interstellar space appears to contain mostly hydrogen, potassium, and calcium atoms, NaH, CH, CN, and other molecules, and particles of metals and crystals of various radii. But even when we suppose the annihilation of the heaviest isotope of uranium, Einstein's relation, $E = mc^2$, gives us 2.4×10^{11} electron volts, which is of the order of magnitude of the less energetic cosmic rays; some cosmic rays have

energies of 10^{14} electron volts and even higher.

Several authors, among them W. F. G. Swann,[42] have supposed that the electric-magnetic processes taking place in sunspots would accelerate electrically charged particles to the velocities required for cosmic rays. To us it seems that the possible changing magnetic fields in the stars are produced by whirls of high-velocity charged particles, and not vice versa. In this case, we come back to the original problem of explaining the origin of high-speed charged particles.

Baade and Zwicky[36, 39] have suggested that the supernovae are the origin of cosmic rays, without giving any concrete mechanism. Later, Zwicky[43] proposed that the density of a cloud of gas ejected from a supernova would eventually become low enough to permit selective action by the tremendous outflowing radiation from the star. This selection would split the electrically charged particles in the cloud (electrons being accelerated more than protons and ionized nuclei), producing layers between which a maximum electrostatic potential of about 8×10^{16} electrostatic units would be set up. Thus, cosmic rays would be produced, according to that theory, by a gigantic stellar electrostatic generator (atom smasher) similar to those which produce streams of charged particles in terrestrial laboratories.

It is doubtful that the separation of particles by this process could ever be so complete as to permit the high potential difference proposed by Zwicky, because the repulsive forces between ions in the lower layer would cause its expansion; the electrons of the outer layer would similarly repel each other and would be attracted strongly toward the positive regions. Also, the very acceleration of any positive particles which the electrostatic gradient might produce would cause those particles to pass through the electron layer and partially neutralize its charge, thereby reducing the effect. Furthermore, there is no evidence of a residual positive charge in the stars themselves.

Our theory of cosmic rays extends the already experimental evidence that transuranic elements of higher and higher atomic number may exist in nature. When the neutron core has a density about equal to that of matter in the nuclei, and its temperature is not greater than 10^7 degrees, we may expect the formation of superheavy very unstable nuclei. From a rough model, we find that it would be possible to build up to atomic numbers of 10,000 and atomic weights of 26,000. It is still possible to pack particles of this total weight within nuclear dimensions less than 10^{-12} cm. At first thought, nuclei of these masses appear fantastic, but there is no fundamental reason why they might not temporarily exist inside neutron cores under the specified physical conditions, and even attain atomic weight of the order of 200,000. It would be possible, by reducing the temperature and increasing the pressure, to build up a huge crystal of neutrons and protons, which would have an extremely short life. The radioactivity of this huge crystal, or better, its destruction, would explain the origin of cosmic rays.

The story of the atomic bomb has shown that each of the fission products of uranium has an energy release of about 100 million electron volts. This process of fission could take place with the unstable superheavy nuclei formed in neutron cores: Coulomb forces acting at the moment the fission starts would produce energies of some 10^{12} electron volts from element No. 10,000. Some cosmic rays, however, have energies as high as 10^{14} electron volts, which could be released in the fission of elements of 200,000 mass units — the size of the huge nuclei-crystal suggested. The resulting secondary nuclei would undergo successive fission processes yielding new neutrons to produce further disruptions until the superheavy elements had broken down into stable nuclei.

The escape of the cosmic radiation from such neutron cores is a problem which might be explained by the very thin atmosphere we have already proposed for a supernova before its explosion. When the explosion actually starts, all the outer matter of the star would expand at great speed, and it would not be difficult for the more energetic particles to escape through this expanding atmosphere. The resulting elastic collisions and interaction with the outer layers of the star would produce a diffusion of the cosmic rays which, together with further collisions with the cosmic dust while the cosmic rays traverse the vast reaches of interstellar space, would produce a rather uniform distribution of cosmic rays in space at the present time.

NOTICE

EFFECTIVE with new subscriptions ordered after June 1st, and with renewals ordered after July 1st, the price of **Sky and Telescope** is increased to $3.00 per year for the United States and possessions; to $3.50 for Canada and countries in the Pan-American Postal Union; and to $4.00 for all other foreign countries. On June 1st, the single copy price by mail becomes 30 cents; over-the-counter, 25 cents.

Current subscriptions expiring with the issue of June, 1946, and thereafter, will be billed at the new rates, but may be renewed at present rates until July 1st. All current subscriptions may be extended for any period at present rates before that date.

SKY PUBLISHING CORPORATION

15. Other problems; conclusion

UNTIL very recent years, the theory of the origin of the solar system that was generally discussed, though not actually adopted, was a modification of the encounter theory. Recently L. Spitzer[44] showed that filaments of matter formed by the gravitational action of a star passing the sun would be dissipated into space before they could condense into planets. Perhaps planetary material might be ejected from transformations taking place in some neutron cores of novae, where the internal explosion is not so uniformly violent as the one corresponding to supernovae. Compact blocks of matter of high density might be released from points not very far from the center of the star, and the passage of one such large "bullet" would ease the passage of additional blocks in the same direction. Large blocks might later evolve into planets; small blocks would form meteors and comets. If a large block were ejected with a greater velocity than the velocity of escape, the system of the star and previously ejected blocks of matter would receive a rotational movement which would be the beginning of the rotation of the planets around the central star. This theory was suggested some years ago by the author.[45]

Spitzer's criticism does not apply to this proposal because of the high density and gravitational energy of the emitted "bullets." The author has computed the conditions for the formation of such planets, but the details are beyond the scope of this article.

(*Continued on page* 19)

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NEWS NOTES

By Dorrit Hoffleit

METEORITES MADE TO ORDER

In the December issue of *Popular Astronomy,* Dr. H. H. Nininger suggests that the development of rockets and atomic bombs may help study the lunar surface. If a rocket, carrying an atomic bomb capable of exploding without the assistance of the atmosphere, could be sent to the moon, the disturbance should be of sufficient magnitude not only to be observed telescopically, but also to dislodge fragments at a velocity sufficient to carry them to the earth!

The velocity of ejection of the lunar particles would have to be only 1.5 miles per second for them to "escape" the gravitational influence of the moon. Those reaching the earth would enter our atmosphere at about seven miles per second, or about one fourth as fast as the average meteorite. The destruction faced by these lunar "meteorites" should therefore be comparatively small. Since the approximate time of arrival of the explosion fragments could be predicted, observing parties would be awaiting the show. Recovered fragments would have important bearing on Nininger's theory of the origin of tektites (see *Sky and Telescope,* Vol. II, Nos. 4, 5, 1943).

NON-SILICA GLASS

Glasses developed for optical, photographic, and ultraviolet studies may no longer contain silica, according to Dr. Frank L. Jones, of the Bausch and Lomb Optical Company, who discussed this subject at the January meeting of the American Chemical Society. Silica used to be considered an essential constituent of glass, but the new types contain phosphates, borates, or fluorides instead. Dr. Jones states, according to Science Service, that glasses intermediate between the older silica and the newer non-silica types are likely to become especially valuable for optical instruments.

MOON ECHOES

In November in this department, we mentioned the possibility of determining lunar parallax by means of radar echoes. On January 25th, newspapers were ablaze with the information that U. S. Signal Corps scientists at Camp Evans, N. J., succeeded on January 10th in getting radar echoes from the moon. The radar pulses, traveling at the speed of light, were reflected back within the expected period of 2.4 seconds. Attempts 10 years previously, by Lt. Col. John H. Dewitt, of Nashville, who is in charge of the current operations, had been unsuccessful because the highest-power transmitters that could then be built would not develop sufficiently powerful signals.

Priority in success is claimed, however, by University of Sydney, Australia, scientists who state that they contacted the moon several times in the fall of 1941. No credence can be given to another report from Sydney, via Reuters, that the sun had been contacted by radar. It is a simple matter, of course, to turn a radar receiver to the sun and get "noise waves" from that powerful radiator of energy; many scientists have performed this experiment.

FAMOUS TELESCOPE MAKER

When George Ellery Hale erected the Solar Observatory on Mt. Wilson in 1904, one of the astronomers he took with him was Professor George W. Ritchey. As soon as the trail up the nearly 6,000-foot mountain was made wide enough, Ritchey hauled up his nearly completed 60-inch reflector. In 1900, Common had already constructed a 60-inch, but it had not proved entirely satisfactory, and Ritchey's on Mt. Wilson was the first successful one.

In 1918, when the 100-inch disk was accepted, it was Ritchey who was charged with grinding, polishing, and figuring it. So it was to a great degree due to this man, who died on November 4th at his home at Azusa, Cal., at the age of 82, that Mount Wilson Observatory has enjoyed its prestige of operating two of the world's finest as well as largest instruments.

Ritchey designed and constructed a 40-inch reflector for the U. S. Naval Observatory; was inventor of an aplanatic reflector; and inventor of a fixed vertical type of reflecting telescope. From 1924 to 1930, he was director of the astrophotographic laboratory at the Paris Observatory.

He used instruments as well as built them — many of the most beautiful photographs of nebulae and clusters taken at Yerkes (early in the century) and at Mount Wilson are his work. He searched for and discovered several novae in distant galaxies.

It may well be said that Ritchey's achievements with big mirrors whetted the appetites of astronomers for more, and led in the direction of the 200-inch telescope now so near to completion.

ORIGIN OF THE CAROLINA BAYS

In current discussions of the "craters" of the southeastern United States (see Astronomical Anecdotes in recent issues), the meteoric theory seems to be fast losing ground, while processes involving various artesian, solution, lacustrine, and aeolian factors are finding greater favor. Now even fish are being accused! In the December *Scientific Monthly,* Major Chapman Grant, of San Diego, proposes that the bays were spawning areas for ocean fish with habits similar to our present-day salmon. In lieu of ascending rivers, these fish sought out the locations of fresh-water artesian springs. In the new theory, wind, currents, and community fish habits are cleverly combined to account for the present observed formations.

Meanwhile, Murray F. Buell, of North Carolina State College, finds *one* of the bays was formed during the last great ice age — Wisconsin time of the Pleistocene. Buell, who determined the age of this bay from the concentration of pollen deposits, suggests the ages of the other bays must be known before their origin can be established. Perhaps bays of slightly different characteristics were formed by different species of fish!

U. S. FELLOWSHIPS TO EUROPEAN WOMEN

Six young women from Europe have come to study at United States universities with aid from the International Study Grant program of the American Association of University Women. Science Service reports that they are studying science, literature, and law. Two are working in astronomy at Radcliffe College and Harvard Observatory, Elsa van Dien, of Holland, and Simone Daro, of Belgium.

MINIATURE PLANETARIUM FOR NAVIGATION

A navigational apparatus that requires no calculations on the part of the observer, and which requires no sextant or star tables, is the invention of Carl J. Crane, Sacramento, Cal., as reported by Science Service.

The device combines the principles of camera obscura and planetarium. It consists essentially of a closed chamber divided horizontally by a sheet of ground glass or other translucent substance. In the middle of the top of the chamber is a lens combination that catches the light of star groups and projects them on the upper surface of the ground glass. Underneath is an internally lighted small sphere, pierced with pinholes in the positions of the principal fixed stars, and mounted with a set of graduated rings that permit settings for calendar date, chronometer time, and so forth. The pinhole points of light from the openings in the sphere are projected against the lower surface of the ground glass. When the actual star images from above and the artificial ones from beneath are in exact agreement, the position of the ship or plane carrying the instrument can be read off directly on a graduated circle.

STUDENTS, DOUBLE STARS, A

Notes on the New York Meeting of the Amer an

By Robert I. Wolff, *College of the City Ne*

Upon the invitation of Professor Jan Schilt, of the Rutherfurd Observatory, the 74th meeting of the American Astronomical Society was held at Columbia University on February 1st and 2nd. It was on the whole a very happy occasion. There was an exceptionally heavy attendance from far and near. Two well-planned and rewarding symposia, together with no less than 38 contributed papers, crowded the two-day session, and the customary society dinner was preceded by an unusually gratifying event.

Professor Henry Norris Russell, one of the leading astronomers of this country and of the world, was presented the Order of the Aztec Eagle, Mexico's highest award to persons outside that country, by Dr. Espinosa de los Monteros, the Mexican ambassador to the United States. Professor Russell was cited for his contributions to astronomy in general and for his co-operation with the astronomers of Mexico.

Some of those who registered Friday morning at the Pupin Laboratories (on top of which building the Rutherfurd Observatory is located) had come a long way. Among them were F. J. Neubauer of California, W. J. Luyten of Minnesota, A. E. Whitford of Wisconsin, F. Henroteau of Canada, L. E. Erro and C. Graef of Mexico. Some 200 others came from the "local cluster." Here and there a uniform reminded everyone how recently we were engaged in active fighting on a mass scale. Although a few astronomers were still occupied with the business of war, most of those present were immersed once more in the problems of their chosen field, astronomy.

At the Friday morning session, Major T. E. Sterne, Aberdeen Proving Ground, described a general method of estimating the accuracy of numerical solutions of differential equations. Not the least interesting part of his paper was the remark that electronic devices are now being developed for machine calculation. This may herald a striking advance in the art and science of computation.

Everyone is familiar with the ordinary hand or motor-driven calculators and knows how fast they are. The machines of the International Business Machines Corporation are much swifter. These devices read numbers from punched cards and operate by sensitive and rapid electrical relays. They achieve a speed of about 10 machine steps per second. This has made possible many problems of astronomical research that could not previously have been undertaken on account of the especially heavy computations involved.

In the new electronic machines, about a hundred thousand machine steps per second may be attained. (Similar developments are expected at the new scientific computing bureau of the I.B.M. under the directorship of Dr. W. J. Eckert, former director of the U. S. Nautical Almanac.) We can, therefore, reasonably hope for renewed attacks on many old problems, yielding more complete and accurate results than previously attained; it is not too hazardous to guess that there will be many a new problem that will tax even the new machines.

Dr. Neubauer reported that in the future Lick Observatory would always try to have at least one member of its staff present at each meeting of the American Astronomical Society, however distant from Mt. Hamilton, Cal., the meeting place might be. He then gave an interesting review of the program of radial velocities of the fainter *B* stars which Lick has been carrying out in conjunction with the Dominion Astrophysical Observatory at Victoria, B. C. Here is a fine example of patient and painstaking effort extending over many years. In all, Lick had obtained 730 and Victoria 1,006 radial velocities. To complete this program over the entire sky, about 400 radial velocities in southern declinations are needed. Dr. Neubauer urged that some adequate instrument in the Southern Hemisphere be employed for this purpose. This paper was the first of several presented during the meeting which reaffirmed the importance of fundamental observational work in astronomy and called upon others in the rising generation to carry it on.

In the recent past at society meetings, the Teachers' Conference has undertaken to discuss the teaching of navigation or ways and means to increase undergraduate interest in astronomy. This time, in a symposium on a college course in practical astronomy, the conference set out boldly to discuss the problem of teaching those students who have selected astronomy as a college major, or who are embarking upon graduate work in the field.

Miss Alice H. Farnsworth, of Mt. Holyoke College, led off with a carefully thought-out syllabus for a two-term course in practical astronomy. Emphasis was placed on classical instruments, observations and reductions of fundamental astronomy, the transit instrument and the determination of time. In addition, relevant mathematical topics such as spherical trigonometry, spherical astronomy, and the theory of errors were given places in the syllabus, as otherwise the student would in general miss them altogether.

Work of high caliber, done by students at the Case School of Applied Science, using the transit, meridian circle, and prismatic astrolabe, was described by Dr. J. J. Nassau. By careful attention on the part of the staff to the initial adjustment and condition of the instruments, as well as skillful and systematic teaching, results of high precision are obtained by the students. In the discussion which followed Dr. Nassau's paper, Lt. Comdr. Fletcher G. Watson described the important use of the pris-

Members and guests at the 74th meeting of the American Astronomical Society, Columbia University, New York City, February 1-2, 1946.

S, AND THE FUTURE

ner**an Astronomical Society**

City New York

matic astrolabe in correcting the charted positions of loran (long-range navigation) bases all through the Pacific. The instrument is simple, portable, easy to use, and capable of yielding results of high precision when accurate time signals are available.

Dr. G. Van Biesbroeck, of Yerkes Observatory, emphasized the value of work with the filar micrometer in enabling students to observe for themselves one of the fundamental phenomena of astronomy, namely, the orbital motion of a visual binary.

The last paper in the symposium at the Teachers' Conference, by Dr. Fred L. Whipple, of Harvard, was on the photographic determination of comet positions. He not only pointed out the importance of this topic in modern astronomy, but submitted an outline of the entire process of photographing a comet, and measuring and reducing its position.

This reporter cannot help but think that it would be far more useful to the majority of astronomy students to get their training in careful, precise observing techniques and systematic and accurate computation by carrying out a number of exercises in the photographic determination of comet and asteroid positions than by determining the time by transit observations or by using the filar micrometer. Few astronomers are now concerned with the determination of time, and few do any work with the meridian circle or micrometer. But no astronomer can afford the lack of a good darkroom technique or an understanding of the astrometric use of the photographic plate. Experience of this kind seems of first importance in procuring a well-rounded astronomical education.

Before the society dinner Friday evening, the award to Professor Russell was made, as already mentioned. At the same time, Professor Erro, director of the Mexican Astrophysical Observatory, presented a check for one thousand dollars to the Henry Norris Russell lectureship fund as a gift from Manuel Avila Camacho, president of the Republic of Mexico. The fund now amounts to nine thousand dollars.

After a pleasant meal, President Harlow Shapley called on Dr. Harold L. Alden, director of the Leander McCormick Observatory in Virginia, to speak. Until recently, Dr. Alden had been in charge of the Yale southern station at Johannesburg. He responded with a brief account of the South African observatories and of their activities.

An important announcement was made at the dinner: an interim meeting of members of the International Astronomical Union will be held in Copenhagen March 7th to 12th, this year. It is hoped that the executive committee and 15 representatives of various countries will convene. Drs. Shapley, Joel Stebbins, and Otto Struve will probably represent the United States. Several Russian astronomers are expected to be present, and an invitation may be made to hold the next general meeting (the last pre-war meeting was in 1938) in southern Russia in 1947 or 1948. Astronomers always have less trouble and lose less time in renewing international ties than most other people.

A report on astronomy and astronomers in Germany, made by Dr. G. Kuiper, of Yerkes Observatory, was read by Dr. Struve. The writer was amazed at the amount of research carried on and even published during the fighting. But to the eternal shame of certain German astronomers, it must be recorded that they did not scruple to "borrow" instruments from the Low Countries or to use forced labor.

Continuing the discussion of international problems, Dr. Bart J. Bok, of Harvard, spoke about the unfortunate affairs of the Dutch astronomers of Java. Later during the meeting, Dr. Peter van de Kamp, of Sproul Observatory, reported briefly on conditions as he observed them recently in France, Belgium, and Holland. A committee of the American Astronomical Society has been appointed to study the problem of aiding needy astronomers abroad.

Saturday morning's session was devoted to a symposium on double stars, with Dr. van de Kamp as chairman. In the opening paper, Professor Russell gave a masterly survey of the whole problem of the determination of the orbit of a binary star. He began by noting that the precision of observations of planets in the solar system is about a thousand times greater than the percentage accuracy with which binary stars can be observed. The binary star is, therefore, far more troublesome and requires observations over the whole of its period to get a satisfactory result, whereas, as is well known, three good observations of a planet will furnish an orbit. Graphical methods are essential in working with binaries, enabling gradual improvement of solutions, but with results no more precise than the observations will allow.

The Princeton astronomer then listed the parameters to be determined for visual, spectroscopic, and eclipsing binaries. The number of parameters is by far the greatest for the last type because so many characteristics of the stars themselves must be included. Among these are the ratio of their brightnesses, their sizes (relative to the orbit), shapes, limb darkening, and other effects that may arise from their nearness to one another. Therefore, a solution requires extensive tables of special transcendental functions; it is always difficult and some-

(*Continued on page* 20)

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BOOKS AND THE SKY

THE RIVER MATHEMATICS

Alfred Hooper. Henry Holt and Company, New York, 1945. 401 pages. $3.75.

THIS BOOK is announced as "an outline of mathematics for the general reader, tracing its development through 40 centuries from the abacus to the marvels of modern engineering." On the frontispiece, mathematics is pictured as a river which splits into two branches, number reckoning and geometry, separated by a barrier. Each of the two branches has flowing into it tributaries, in many cases representing the contributions of individuals. The barrier is finally broken down by the development of trigonometry, analytic geometry, and calculus, to form the mighty flood of present-day mathematics. This figure, with the principal names and dates listed alongside, is astonishingly suggestive, and successfully presents a bird's-eye view of the growth and unity of the subject.

To a large extent, it also faithfully represents the contents of the 15 chapters. An exposition of the early beginnings is followed by an exploration of the branch of arithmetic and algebra through the solution of quadratic equations, the slide rule, and logarithms. An exploration of the geometrical branch follows. Deductive geometry is omitted to make room for land measurement, something about vectors and about co-ordinates. These preparations lead up to the final chapters on trigonometry and the rudiments of analytic geometry and of calculus, with a brief appendix on imaginary numbers.

The early pages raise the reader's expectation that the book may be principally a history of the subject. In a sense it is, but at the same time it reads in many places as a home-study course in high school mathematics, always with frequent historical notes to enliven the discussion. This was unavoidable: in order to be comprehensible to the general reader each chapter had to build the fundamentals of the topic assigned to it. All this is done with considerable skill, with a knowledge of successful teaching methods and, above all, with a true love for the subject.

DIRK BROUWER
Yale University Observatory

THE CALENDAR STICK OF TSHI-ZUN-HAU-KAU

Robert H. Merrill. Cranbrook Institute of Science, Bloomfield Hills, Mich., 1945. 11 pages. 35 cents.

STRANGE it is that as short a time as a century has clouded and obscured our knowledge of the interests and culture of such American Indians as the Winnebago tribe of eastern Wisconsin. Particularly interesting to amateur astronomers is the calendar stick which is treated in this little pamphlet of the Cranbrook Institute of Science. Perhaps Tshi-zun-hau-kau even took his calendar stick with him when he went to Washington in 1828, but today we find ourselves only able to guess at the meaning of many of the devices carved thereon by this red-skinned watcher of the heavens. The calendar stick, according to Mr. Merrill, is considered unique among such surviving records for the North American Indians.

Days in units of 10, moons of 30 days each, 12 plus to a year, are all plainly carved on this Winnebago calendar. The moon's phases and conjunctions with planets are definitely marked, so that an assiduous calendar student could probably work out the exact year (or two) recorded in this manner by Tshi-zun-hau-kau. The pamphlet diagrammatically and photographically reproduces the markings on the calendar stick, and presents a partial explanation of their significance.

C. A. F.

NEW BOOKS RECEIVED

Fotografia Astronomica, *Jose Galli*, 1945, *Correo Fotographico Sudamericano.* 252 pages. Price not given.

An interesting and well-illustrated presentation, in Spanish, of the principles of astronomical photography, including a description of instruments and basic optical concepts involved.

You and the Universe, *John J. O'Neill*, 1946, *Ives Washburn.* 328 pages. $3.50.

Subtitled "What Science Reveals," this book contains material on general science, including astronomy, all originally published in the New York *Herald Tribune*, of which the author is science editor.

ORIGIN of the SOLAR SYSTEM

By Willis

The theory that, in case two stars should collide, a tenuous filament of hot gases would result is discussed and shown to be untenable.

The significance of the circular orbits of some of the planetary satellites and the elliptical orbits of the others is here for the first time pointed out.

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HOLLYHURST PUBLISHING COMPANY

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ASTRONOMICAL ANECDOTES

RADAR-MOON MADNESS

WELL, here we go again! With a $500,000,000 experiment by the Navy to show how destructive an atomic bomb will be at sea and the Army announcement that radar signals have been bounced from the moon, public imagination may be stirred to a point such that the appropriations for scientific experiments won't be cut right away.

As for "Project Diana," the stuff that has appeared in the press is really too much. Most of it must have been written by those who apparently have no acquaintance with radar responses or the technique involved. Either that, or the world has become so sated with marvelous things that nothing can surprise anyone any more. I wonder how much excitement would be created if one of us should say, casually, at the club, "As I was telling a fellow from Mars only this morning. . . ."

But now we read that radar is going to be used not only to chart the moon, but for Mars and Venus and the sun and stars. What can we possibly learn from a star by radar? Or of the sun? Little enough, it seems to me, is to be learned even from the nearby moon.

Theoretical considerations may indicate radar's accuracy to be a fraction of a mile, which nicety Naval Observatory astronomers are quoted as desiring to better our knowledge of the distance to the moon, but what does the radar response from the moon mean? Would it give the distance to the average moon — to its center of gravity? Or the distance to the flat surface most nearly normal to the "line of radar"? Or the distance to the top of the highest mountain or crater wall?

The published pictures of the radarscope showed the response from the moon as a hump with a width of about 60,000 miles. We know the moon's distance more accurately than that! This was due to the fact that the pulse lasted about a third of a second. And to what part of the moon did the initial upkick pertain? To gauge the moon's distance, we must be sure that the radar pulse gets out and gets back without any refraction or other distortion in the ionosphere.

Undoubtedly there are experiments in which very narrow radar beams have been used, but the narrowest published value that I have seen is such that at a mile the beam is 18 feet wide. At the distance of the moon, such a beam would be about 800 miles wide. To whittle it down to a mile is obviously some job, but maybe it will be done.

It is rather astounding to read that radar may enable us to see the deep, still pools of water standing in the cracks of the lunar surface. This amazing water has the power of resisting evaporation under an atmospheric pressure no more than 1/10,000 the earth's!

Mapping the surface of Mars, and even of Venus, also appears to be just around the corner, according to press accounts. Shooting for a mile on Mars would mean getting the radar beam down to the size of a dime at 350 miles, at times of the planet's most favorable oppositions. A mile of difference of elevation on Mars requires *precise* measurement of the time differences to 1/100,000 of a second. I know radar technique demands microseconds, but that kind has not so far been tried through the ionosphere, and I'm still worried about the refraction.

There was once a radio program during which a sepulchral voice intoned, several times each week, "Electronics!" Everything, it seems, was to be done by electronics — everything, that is, that wouldn't be done through the use of plastics. Between the two of them, the bright new world of the future was a setup. About a year ago I saw a sign in a New Jersey city, as I passed through by train. A gaudy display in bright yellow and black, it ornamented the top of a narrow old three-story loft building. The fellow that bought the sign has the world by the tail. For the legend reads, "The Electronic Plastics Corporation."

R. K. M.

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Planetarium Notes

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SCHEDULE: Tuesdays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.; building closed Mondays.

STAFF: *Director,* Wagner Schlesinger. *Other lecturer:* Harry S. Everett.

March: THE SEASONS. The changing altitude of the sun, and the differing lengths of day and night, resulting from the motions of the earth, are shown to be the causes of the seasons.

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Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers*: Nicholas E. Wagman, J. Frederick Kunze.

March 3-April 6: BY ROCKET TO THE MOON. Radar contact with the moon turns our thoughts to the first rocket trip, closer now with atomic power. Here's a realistic and exciting "preview."

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20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 3050

SCHEDULE: 3 and 8:30 p.m. daily; also 4 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

March: PLANETS AND THEIR WAYS. Earth's fellow travelers differ markedly from our planet and from each other. The planetarium projector and auxiliary apparatus will show us how they appear to move and how they really move.

April: TRIP TO THE MOON.

GRIFFITH PLANETARIUM

P. O. Box 9866, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Friday and Saturday, 3 and 8:30 p.m.; Sunday at 3, 4:15, and 8:30 p.m.

STAFF: *Director,* Dinsmore Alter (on military leave). *Acting Director,* C. H. Cleminshaw. *Other lecturer:* George W. Bunton.

March: THE NORTHERN LIGHTS. The beautiful colored lights of the aurora as seen from the arctic regions; the midnight sun and polar skies.

April: EASTER AND THE CALENDAR.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Marian Lockwood, Robert R. Coles, Catharine E. Barry, Shirley I. Gale.

March: EYES OF THE ASTRONOMER. This month we discuss the many interesting instruments with which the astronomer explores the depths of space to learn the secrets of the stars.

April: ATOMS, STARS AND COSMIC BOMBS.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

SUNSPOTS, AURORAE, A COMET, AND A NOVA

NEVER A DULL MOMENT is the rule in the heavens these days. As if in response to popular interest created by the announcement of radar contact with the moon, the celestial bodies are vying with each other to provide phenomena designed to keep amateurs observing at all hours of the day and night.

Dominating the observing news is the renewed activity on the sun, exemplified by the accompanying photograph taken by the Reverend William M. Kearons, of West Bridgewater, Mass., on February 2nd, at 12:55 p.m. EST. The large group of spots could be seen with the naked eye, according to Floyd L. Arnold, Jr., of Brooklyn, N. Y., and others. Mr. Arnold reported also that seven spots were visible in a 50x telescope, five of them forming the large group in the upper portion of the sun.

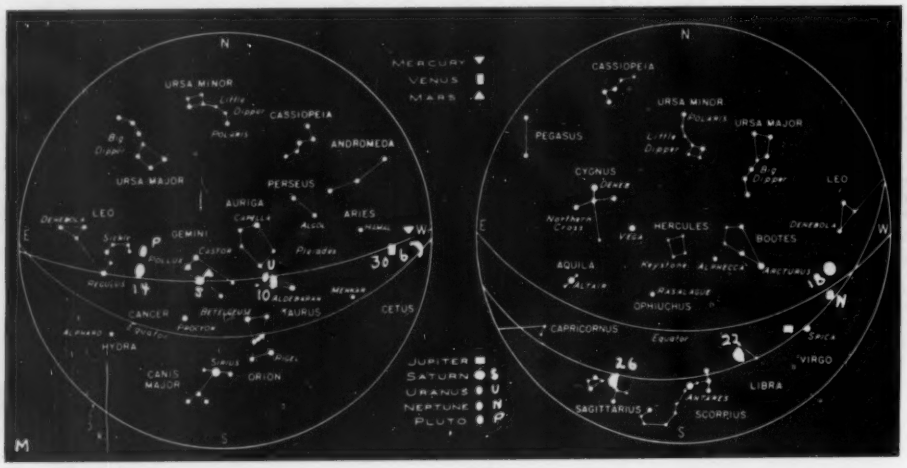
On February 2nd, according to the New York **Times**, international radio communication suffered spasmodic interruptions; Mackay Radio and Telegraph Company reported a complete fadeout over the Atlantic from 4:00 to 7:00 a.m. Other parts of the world were similarly affected.

An expected aurora borealis occurred on Thursday evening, February 7th, with a brilliant coronal outburst featuring the display in New York and New England, dimmed but not outshone by the waxing moon. Colors and rapid flashing were notable features of the display.

Meanwhile, on February 2nd, M. Timmers, of the Vatican Observatory, discovered a 9th-magnitude comet at $9^h\ 47^m.5$, + 42° 24′, in the constellation of Ursa Major. Its daily motion was given as $1^m\ 41^s$ west and 1° 12′ north. Harvard patrol plates showed the comet bright enough to register on January 23, 24, 28, and 29, and a plate taken on February 4th with an 8-inch refractor indicated a fairly sharp nucleus with no conspicuous tail.

Further positions were reported from Lick, Lowell, and Yerkes observatories, and Dr. L. E. Cunningham computed a preliminary orbit, indicating the following positions: Feb. 21, $9^h\ 1^m$, +61° 49′;

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 5:30 a.m. local time on the 7th of the month, and at 4:30 a.m. on the 23rd. At the left is the sky for 7:30 p.m. on the 7th and 6:30 p.m. on the 23rd. The moon is shown for certain dates by symbols which give roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury can be easily observed during the first half of the month shortly after sunset. Greatest elongation occurs March 9th, when Mercury is 18° 17′ east of the sun. Although the planet is then near perihelion, the position of the ecliptic with reference to the horizon at sunset makes this the most favorable apparition in the evening sky for Northern Hemisphere observers this year. On March 1st, Mercury sets at 7:00 p.m. local time, an hour and 10 minutes after sunset; the planet is then as bright as Canopus, —0.9 magnitude. At elongation it sets at 7:30 p.m. local time, or 1½ hours after the sun; its magnitude is then —0.1, or about one half as bright as on the 1st. Because the planet rapidly approaches the sun, it will be difficult to observe after the 20th of the month.

Venus continues to increase its distance from the sun in the evening sky. By the end of the month the planet can be picked up with the naked eye low in the west, setting about an hour after the sun.

Earth passes heliocentric longitude 180° on March 21st, at 5:33 GCT. The sun appears to cross the celestial equator and spring begins in the Northern Hemisphere, autumn in the Southern.

Mars passes Saturn for the third time since October, conjunction occurring at 1:00 GCT on March 19th. Mars is slightly dimmer than Saturn; both planets are still in Gemini.

Jupiter rises at about 9:30 p.m. local time on the 1st and successively earlier throughout March as it approaches opposition in April. It is a few degrees from Spica, in Virgo, the planet outshining the star by over three magnitudes.

Saturn remains almost stationary a few minutes of arc from Delta Geminorum. At sunset, Saturn is close to the meridian, and it sets a few minutes before Mars, at 3 a.m. local time. The moon is close to the two planets on the night of March 11th.

Uranus is in Taurus, at $4^h\ 49^m$, + 22° 29′ (1946), on the 15th of the month.

Neptune is at opposition on March 28th, therefore rising at about sunset. It is situated between Gamma and Eta Virginis, and is of magnitude 7.7. The position at opposition is $12^h\ 29^m$, —1° 29′ (1946).

Every planet can be seen some time between sunset and 10 p.m. local time about March 15th, Uranus and Neptune (and perhaps Venus) requiring some optical aid. Pluto, of course, is visible only in a large telescope.

EDWARD ORAVEC

PHASES OF THE MOON

New moon	March 3, 18:01
First quarter	March 10, 12:03
Full moon	March 17, 19:11
Last quarter	March 25, 22:37

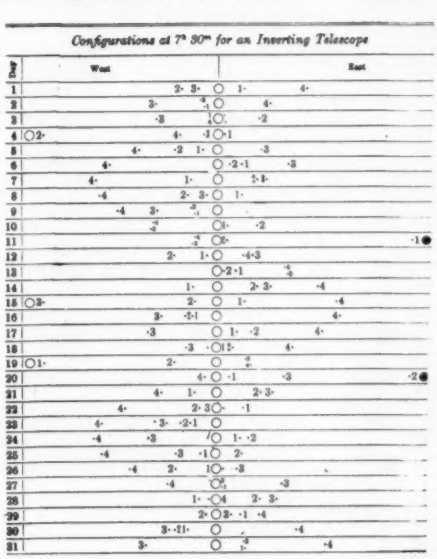
ZETA BOOTIDS

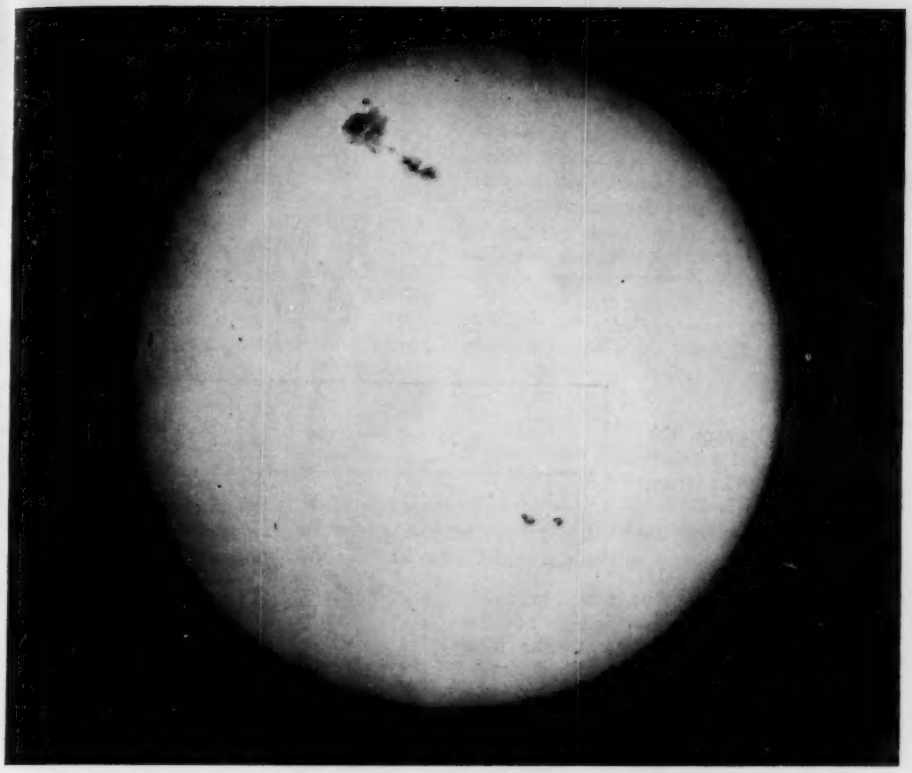
From March 10th to 12th, swift meteors characteristic of the Zeta Bootids, a minor meteor shower, may be seen.

E. O.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**





The recent large group of sunspots, which caused considerable disruption of radio communications, and was closely followed by an auroral display, as photographed by William M. Kearons on February 2nd, at 12:55 p.m. EST.

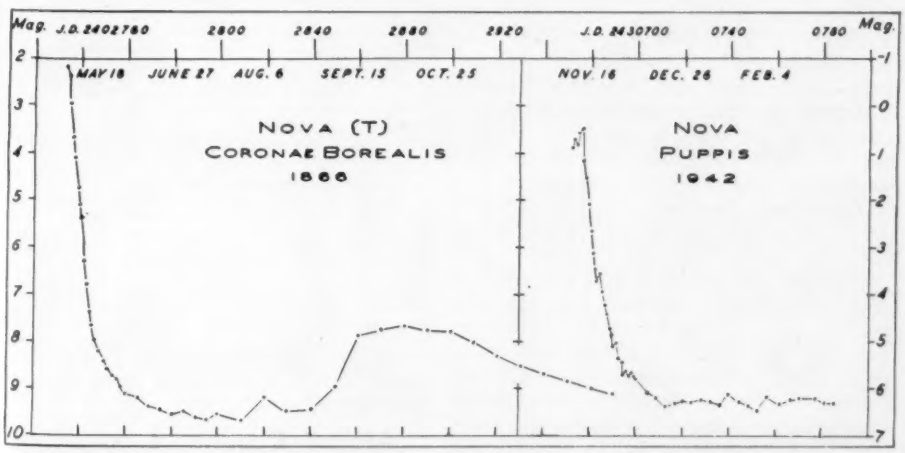
Mar. 1, $8^h\ 30^m.3$, +67° 37′; Mar. 9, $7^h\ 54^m.9$, +71° 46′.

Saturday morning, February 9th, the Harvard clearinghouse received the following telegram from Dr. Otto Struve, director of Yerkes Observatory. "Armin Deutsch discovered T Coronae Borealis magnitude 3.2 at 8:30 U.T. Feb. 9. Spectrum by him, Morgan, and Munch shows hydrogen absorption lines 10 angstroms wide. Velocity about 4000 kilometers. Hydrogen emission undisplaced at 12 angstroms wide."

A recurrent nova! The comment by Dr. Cecilia Payne-Gaposchkin, one of the Harvard astronomers who were pleased and excited with the news, typifies how astronomers everywhere must feel at this second outburst by the same star. (In 1866, T Coronae Borealis was a nova of the 2nd magnitude, as shown by the light curve below.) She said, "We all knew it was going to happen, but not just when." At this writing (February 10th) it is not known whether the star was discovered by Dr. Deutsch before reaching maximum brilliance or not, but if it repeats its performance of 80 years ago, it will fade very rapidly.

Usually this variable is of the 10th magnitude, but lately changes in its brightness and spectrum have been foreshadowing its present flareup. As a 3rd-magnitude star it was brighter than Epsilon in the Northern Crown, near which T is situated (see position on A.A.V.S.O. chart and in Norton's **Star Atlas**).

Those who wish to watch a continuing performance on the celestial stage will find Mars, Saturn, and Castor and Pollux in an interesting series of configurations throughout this month.



In 1866, after a rapid fall from maximum, T Coronae Borealis brightened about two magnitudes. It is compared with Nova Puppis 1942.

OCCULTATION PREDICTIONS FOR MARCH

8-9 **148 B Tauri** 6.0, 3:50.1 +17-10.1, 5, +82° 0° Im: **A** 2:43.5 0.0 —2.7 125°; **B** 2:36.1 —0.2 —2.2 113°; **C** 3:00.1 . . . . . 158°; **D** 2:39.2 —0.3 —2.9 125°.

10-11 **1 Geminorum** 4.3, 6:00.8 +23-16.1, 7, +80° +10° Im: **F** 7:50.2 +0.4 —1.3 113°; **G** 7:23.4 —0.4 —1.2 77°; **H** 7:44.7 0.0 —2.1 124°; **I** 7:20.8 —0.6 —1.4 89°.

12-13 **82 Geminorum** 6.2, 7:45.3 +23-16.6, 9, +65° 0° Im: **A** 23:34.7 —1.8 0.0 108°; **B** 23:33.8 —1.6 +0.5 97°; **C** 23:27.3 —1.9 —0.5 119°; **E** 23:05.2 —1.2 +0.6 105°; **F** 22:55.9 —1.6 —1.0 134°.

19-20 **598 B Virginis pr.** 6.5, 13:52.1 —7-47.6, 16, +83° +2° Em: **A** 10:40.9 —0.7 —2.6 335°; **C** 10:45.8 —0.9 —2.4 326°; **E** 10:28.4 —1.3 —2.1 317°; **F** 10:35.4 —2.0 —1.5 292°; **G** 9:40.9 —1.3 —0.8 306°; **H** 9:34.1 —3.1 +0.6 264°; **I** 9:28.5 —1.5 —0.1 291°.

20-21 **6 B Librae** 6.2, 14:34.1 —12-04.6, 17, +78° 0° Em: **A** 8:18.8 —1.5 —1.5 315°; **B** 8:13.0 —1.4 —1.4 318°; **C** 8:15.4 —1.9 —1.1 302°; **D** 8:06.6 —1.6 —1.0 307°; **E** 7:46.6 —2.1 +0.1 281°; **G** 7:17.5 —1.1 +1.3 275°; **I** 7:05.2 —1.1 +2.1 259°.

21-22 **32 Librae** 5.9, 15:25.2 —16-31.8, 18, +69° —8° Em: **F** 11:00.7 —1.7 —2.4 330°; **G** 10:04.4 —0.2 —1.5 352°; **H** 10:14.0 —1.6 —0.6 307°; **I** 10:01.7 —0.6 —0.7 332°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +30°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
	I +123°.1 +49°.5

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the British **Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

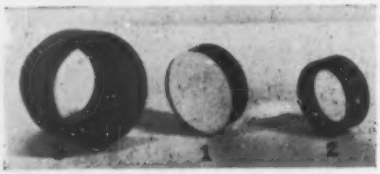
MINIMA OF ALGOL

March 1, 17:22, 4, 14:12; 7, 11:01; 10, 7:50; 13, 4:40; 16, 1:29; 18, 22:18; 21, 19:07; 24, 15:57; 27, 12:46; 30, 9:35.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

Achromatic Wide-Angle Four Element Telescope Objective



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(3) Metal mounting (aluminum-magnesium alloy).

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GLEANINGS FOR A. T. M.s

Simplified Computations for Achromatic Lenses

R. W. WOODING, of Roxbury, Mass., has evolved simplified equations for the radii of the surfaces of achromatic lenses, which it seems to us are easier for the non-mathematical amateur to use than the more involved expressions usually found in most articles on the subject.

Usually, the amateur who wishes to construct for himself an achromatic lens does not want to compute a thoroughly corrected lens, but is satisfied to adopt a standard form and adapt it to the focal length he desires. Haviland, in **Amateur Telescope Making Advanced,** gives three time-tested forms which have been found to work satisfactorily: the one where the crown is equiconvex (K = —1), and those where the ratio of radii of the two crown surfaces is 2/3 and 3/2 (K = —2/3 or —3/2). In commercial designs, where the crown is not equiconvex, it is more common to cement the side of steeper curvature.

The equations Mr. Wooding presents are as follows:

$$r_1 = \frac{F(K-1)(N_c-1)(V_c-V_f)}{KV_c}$$

$$r_2 = Kr_1;\ r_2 = r_3$$

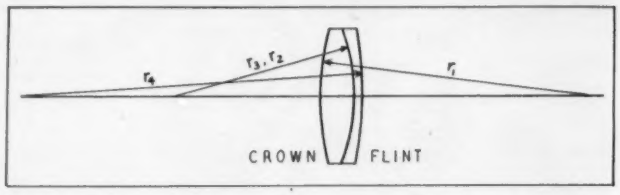
$$r_4 = \frac{F(K-1)(N_c-1)(N_f-1)(V_c-V_f)}{(N_f-1)V_c + (K-1)(N_c-1)V_f}$$

In the above expressions, K is the ratio of the radii of the crown surfaces; F is the desired focal length of the complete lens; N_c and N_f are the indices (for the D-line of sodium) of crown and flint, respectively, and V_c and V_f are the V-values for crown and flint, respectively. The V-values, together with the refractive indices, will be found in the glass catalogues, or, preferably, stamped on the glass blanks.

The radii of the outside surface of the crown, the inside surface of the crown, the inside surface of the flint, and the outside surface of the flint are, respectively, r_1, r_2, r_3, and r_4. Remember that if the center of curvature lies to the right, the radius is positive; if it lies to the left, the radius is negative, the surfaces being numbered from left to right in the order in which they are met by the incident light. It is customary to draw lenses with the light incident from the left, as in the figure, where r_1 is positive, and r_2, r_3, and r_4 are negative.

If the lens is to be cemented, we must have $r_2 = r_3$. The equations then give the values for the radii by the substitution of known quantities.

In this diagram, the light is to be taken as coming in from the left.



IN FOCUS

(*Continued from page 2*)

Pickering, W. H. Named for the American student of the moon and of Mars, William H. Pickering (1858-1938). See also Messier. Two conspicuous rays diverge toward the east from this feature.

Secchi. A small crater whose walls are open to the southward, named for Father Secchi (1818-1878), one of the earliest workers in stellar spectroscopy.

Taruntius. An irregular plain of good size, whose interior seems partly filled with lava, and whose walls are low.

Torricelli. A ring plain with a small feature adjacent to it, with their common wall broken down. The formation seemingly stands in the center of a large and much older ring. Named for a 17th-century physicist who discovered the principle of measuring atmospheric pressure with mercury in a glass tube; hence, the barometer was originally called a Torricellian tube.

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Choosing the form of the lens will give the value of K. For example, if the crown is equiconvex, then K = —1. It should be noted that these equations are based only upon the achromatic condition, and will give a **chromatically** corrected lens for any value of K whatever. The proper choice of K will determine whether the lens is corrected for **spherical** aberration. As was mentioned above, values of K equal to —1, —2/3, and —3/2 have been found from experience to give reasonably good spherical correction. Other values of K may be as good, or even better, but no one has yet come forward with simplified methods of determining suitable values.

The editor will be glad to furnish copies of the derivation of the above equations upon request. Address Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass., and ask for Technical Bulletin No. 104.

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COSMOGONICAL IMPLICATIONS OF THE ATOMIC BOMB

(*Continued from page* 10)

As for the expanding universe, along lines proposed by Lemaitre[46] and others, we may imagine that before the universe exploded all matter was in the form of neutrons. This huge primitive star would have contracted within a curved Einstein universe until it arrived at the critical conditions previously proposed for a neutron core. At that moment, the neutron primitive star would have exploded (as a super-supernova) and given rise to the various galaxies now observed all receding from each other. Secondary explosions of similar type would give rise to the diverse forms of galaxies and nebulous matter in space. Remaining free neutrons would build up new neutron core stars which could later form supernovae, novae, and planetary systems.

A direct inference from this mechanism is that the original velocity of the explosion had to be much greater than the present velocity of recession of the exterior galaxies; consequently, this velocity ought to be diminishing with increasing time, a point which might be subject to observational confirmation. (Don't confuse this statement with the observed fact that the velocity of recession increases with the distances of the galaxies.) Our theory could provide a concrete physical mechanism for the "initial atom" of Lemaitre, which, according to him, took part in the original explosion.

The thoughts presented in this series of articles are to be considered, as are most scientific proposals, as attempts along the way to a clearer understanding of the universe, and by no means are they to be taken as proven hypotheses. Their value is in the way they may lead various investigators to develop new theories based on our proposed interpretation of observed facts.

We have sought to indicate some of the astrophysical problems which may find new solutions on the basis of knowledge gained in nuclear physics research for the atomic bomb. It may be that even our universe, including the human race, may be the result of a colossal primitive and natural atomic bomb. It would be a terrible irony of fate if men, by lack of unselfishness and social understanding, completely destroy themselves with atomic bombs of their own invention.

THE END

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STUDENTS, DOUBLE STARS, AND THE FUTURE

(*Continued from page* 13)

times indeterminate. When a solution is obtained for an eclipsing system, the resultant physical characteristics attributed to the two stars must be in accord with physical theory as well as with the observed light curve. If it is not, the solution must be modified until the best compromise is obtained.

The next speaker was one of Russell's students, Professor John E. Merrill, now at Hunter College in New York. He had set himself the double task of providing new, more complete, and more accurate tables for eclipsing binary orbit determination, and of devising rapid graphical methods for preliminary solutions so that less time would be consumed in following false leads with heavy equipment. He considered mainly the idealized case of circular, sharp-edged stars, darkened toward the limb according to the so-called cosine law. His extensive tables and nomographs are soon to be published in the Princeton University Observatory *Contributions;* this work is bound to be of great use to all future students of eclipsing stars.

A synthesis of the known relations between the components of double star systems was next presented, by Dr. Cecilia Payne-Gaposchkin and Dr. S. Gaposchkin, of Harvard. These relationships are best exhibited by plotting each double star's components on a spectrum-luminosity diagram and connecting the two points with a straight line. A glance then shows that binaries are teamed up in most of the ideally possible combinations. Eclipsing stars, red-blue binaries, and visual binaries were all included by the Gaposchkins. If the components of binary stars are assumed to be of the same age, then the members of many pairs must differ greatly either in central temperature (energy source) or in constitution. The latter appears to the Harvard astronomers to be the preferable alternative.

Included in the symposium papers was one by Dr. Dirk Brouwer, of Yale University Observatory, who has made a study of the dynamics of binary systems consisting first of a rigid spheroid and a mass particle, then of a rigid spheroid and a rigid sphere, and lastly, of two rigid spheroids. He has found it possible to attack these problems along the lines of Hill's lunar theory, and he has indicated the type of developments needed and obtained the main results. There is a possibility, he pointed out, that an illustration of the first part of the theory may be found in the motion of Jupiter's fifth satellite. More and better observations of this faint and difficult object are needed before this can be decided.

The chairman next summarized a paper by Dr. A. H. Joy, of Mount Wilson Observatory, on spectroscopic investigations of binary stars. The spectroscope can show the duplicity of stars which have periodic radial velocity variation and of stars with composite or combination spectra. Dr. Joy points out the need for further spectrographic investigation of visual double stars, especially for close pairs and those whose components have considerable difference in magnitude.

A similar appeal for further visual double star work was made in a paper sent by Dr. Robert G. Aitken, the well-known veteran observer of visual doubles, now over 80 years of age. He suggested that no special effort be made to discover new doubles, but urged that more and better measures of the known ones be carried out. He gave detailed criteria for the selection of doubles to be measured by visual, interference, and photographic methods.

This call found an immediate and independent second in Dr. Van Biesbroeck's plea to young astronomers not to neglect a field of observation only accessible to visual work. "Each generation," he said, "carries the obligation to the future to record the behavior of these binaries until a more or less reliable orbit is secured."

Traditionally, only large refractors have been used for micrometric work (visual double star observations, in particular). By a fortunate result of wartime stringencies, Dr. Van Biesbroeck had an opportunity to try the 82-inch McDonald Observatory reflector on visual doubles. He found that at moments of best seeing the expected theoretical advantage of the great aperture of the reflector was fully realized. He used the Cassegrainian focus, corresponding to a focal length of 90 feet, and could make real measures on stars as close as 1/10 second of arc, whereas in the 40-inch Yerkes refractor these stars would be seen partly merged. Operators of large reflectors have the opportunity, Dr. Van Biesbroeck pointed out, to catch those binaries which move rapidly into periastron, getting close enough to be just below the resolving power of the great refractors; they have thus hitherto been lost to observation during the critical parts of their orbits.

Three papers on rather special topics brought the symposium to an end. Dr. Luyten, of the University of Minnesota, in his survey of stars of large proper motion and low luminosity, finds three per cent of the doubles he has examined to have a white dwarf as one component. There are, perhaps, more such white dwarfs than single ones, which situation will lead to important information on the masses of these exceptionally dense stars. Dr. Alden gave a resume of the few reliable astrometric orbits of spectroscopic binaries. Finally, the society treasurer, Dr. Keivin Burns, of the Allegheny Observatory, described the double star program which has for 30 years formed part of the parallax observations there.

It is, of course, a characteristic feature of all the sciences that any probing discussion of their current problems leads quickly to questions that cannot be immediately answered. One saw this frequently at the New York astronomical meeting, and saw also notable examples of the fact that in astronomy, in particular, progress often depends upon long-term programs of fundamental observations and international good will, stability, and co-operation.

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Here's an unusual opportunity to secure a fine set of Binoculars . . . at a tremendous saving of money. Build them yourself with all of the very same optics contained in the Navy's 7 Power Glasses . . . . the Binoculars which received such wide acclaim during the war. Depending on your choice, you may buy a perfect set of Lenses and Prisms for the Binocular construction job, or a set of seconds (exactly the same units, but Lenses are uncemented and have slight imperfections). If, however, you wish to construct a Monocular (½ a Binocular) you may do so, choosing either perfect components or seconds. The Monocular sets comprise ½ quantities of the same optics required for the Binocular. The full Perfect Binocular set comprises the following:— 2 Cemented Achromatic Eye Piece Lenses, 17.5 mm. diam; 2 Eye Field Lenses; 4 Porro Prisms; 2 Cemented Achromatic Objective Lenses, diam. 52 mms. Complete assembly directions included.
Stock No. 5102-Y —
Perfect Binocular Set ..... **$25.00 Postpaid**
Stock No. 5103-Y —
Perfect Monocular Set ..... **$12.50 Postpaid**
Stock No. 5105-Y —
Seconds for Binoculars ..... **$11.00 Postpaid**
Stock No. 5104-Y —
Seconds for Monocular ..... **$5.50 Postpaid**

NOTICE! If you buy both the Binocular Optics and the Binocular Metal Parts, your purchase becomes subject to 20% Federal Excise Tax. Be sure to add amount covering tax to your remittance or your order cannot be filled.

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections Which We Guarantee Will Not Interfere with Their Use. Come Neatly Packed and Marked.

TO KEEP POSTED on all our new Optical Items, send 10c and your name and address to get on our regular "Flash" mailing list.

35 MM. KODACHROME PROJECTING LENS SET—Consists of Achromatic Lens for projecting, plus a Condensing Lens and piece of Heat Absorbing Glass with directions.
Stock No. 4025-Y ..... **$1.95 Postpaid**

SPECTROSCOPE SETS . . . These sets contain all Lenses and Prisms you need to make a Spectroscope plus FREE 15-page Instruction Booklet.
Stock No. 1500-Y—Hand Type Spectroscope, **$3.45 Postpaid**
Stock No. 1501-Y—Laboratory Type Spectroscope ..... **$6.50 Postpaid**

RIGHT ANGLE PRISM—Flint Optical Glass, size 41 mm. by 91 mm. by 64 mm. Use in front of camera Lens to take pictures to right or left while pointing camera straight ahead. Also used in front of camera Lens to reverse image in direct positive work. Two of these Prisms will make an erecting system for a Telescope.
Stock No. 3076-Y .....**$3.00 Postpaid**

REMARKABLE VALUE!
$141.01 Worth of Perfect Lenses for Only $10.00
Complete System from Artillery Scope (5X). 9 Lenses, low reflection coated, **absolutely Perfect.** Diameter range from 1 1/3 inches to 2 1/5 inches. Used for Telescopes and hundreds of other uses.
Stock No. 5019-Y ..... **$10.00 Postpaid**

SPECIALS IN LENS SETS

Set No. 1-Y — "Our Advertising Special" — 15 lenses for $1.60 Postpaid, plus 10-page idea booklet. For copying, ULTRA CLOSE-UP SHOTS macrophotography, experimental optics, magnifying and for making a two power f/16 Telephoto Lens, "Dummy Camera," Kodachrome Viewer, DETACHABLE REFLEX VIEW-FINDER for 35 mm. cameras, stereoscopic viewer, ground glass and enlarging focusing aids, TELESCOPES, low power Microscopes and for many other uses.

NEW 50-PAGE IDEA BOOK "FUN WITH CHIPPED EDGE LENSES"
Contains wide variety of projects and fully covers the fascinating uses of all Lenses in sets listed above . . . only **$1.00 Postpaid.**

RETICLE SET—5 assorted, engraved reticles from U. S. Gunsights. **Stock No. 2035-Y..$1.00 Postpaid**

OPTICS FROM 4-POWER PANORAMIC TELESCOPE
Excellent condition. Consists of Objective Prism, Dove Prism, Achromatic Objective Lens, Amici Roof Prism, Eye Lens Set (. . . a $60.00 value).
Stock No. 5016-Y .....**$6.00 Postpaid**

RAW OPTICAL GLASS

An exceptional opportunity to secure a large variety of Optical Pieces both Crown and Flint glass (seconds) in varying stages of processing. Many prism blanks.
Stock No. 703-Y—8 lbs. (min. wt.)—**$5.00 Postpaid**
Stock No. 702-Y—1½ lbs. .....**$1.00 Postpaid**

ALL THE LENSES YOU NEED TO MAKE YOUR OWN TELESCOPE!

ALL ARE ACHROMATIC LENSES

GALILEAN TYPE — Simplest to Make but has Narrow Field of View.

Stock No. 5004-Y—Small 2 Power Pocket Scope .....**$1.00 Postpaid**

Stock No. 5018-Y—4 Power Telescope, **$1.25 Postpaid**

PRISM TELESCOPES—Use Prism instead of Lenses to Erect Image. Have wide field of view.

Stock No. 5010-Y—6 Power Telescope, **$3.00 Postpaid**

Stock No. 5012-Y—20 Power Telescope, **$7.25 Postpaid**

ACHROMATIC LENSES

Stock No.	Dia. in mms.	F.L. in mms.	Price
6158-Y*	18	80	$1.00
6159-Y	23	51	1.25
6161-Y	24	48	1.25
6162-Y	25	122	1.25
6164-Y*	26	104	.80
6165-Y	27	185	1.00
6166-Y	29	54	1.25
6168-Y	29	76	1.25
6169-Y	31	122	1.50
6171-Y	32	171	1.00
6173-Y*	34	65	1.00
6176-Y*	38	131	1.00
6177-Y*	39	63	1.10
6178-Y*	45	189	1.50
6179-Y*	46	78	1.25

*ASTERISKED ITEMS are uncemented, but FREE cement and Directions included with uncemented sets.
USES:—Use these Lenses for making Projecting Lenses, Low Power Microscope Objectives, corrected Magnifiers, substitute enlarging Lenses, Eye-Piece Lenses, Macro-photography, Gadgets, Optical Instruments, etc., etc.

MAGNIFIER SET—5 magnifying Lenses—Powers from 1 to 10.
Stock No. 1026-Y.... .....**$2.00 Postpaid**

LENS CLEANING TISSUE—In spite of paper shortage, we offer an exceptional bargain in first quality Lens Cleaning Tissue. You get 3 to 4 times as much tissue as when you buy in the ordinary small booklets. One ream—480 sheets—size 7¾" x 10¾".
Stock No. 704-Y ..... **$1.50 Postpaid**

MICROSCOPE SETS

Consisting of two Achromatic Lenses and two Convex Eye Piece Lenses which you can use to make a 40 Power Pocket Microscope, or 140 Power Regular Size Microscope. These color corrected Lenses will give you excellent definition.
Stock No. 1052-Y ..... **$3.00 Postpaid**

Consisting of Prism, Mirror and Condensing Lens. These used together with Stock No. 1052-Y will make an excellent Microprojector enabling you to get screen magnification of 400 to 1000 Power according to screen distance.
Stock No. 1038-Y ..... **$2.00 Postpaid**

BIG DOUBLE CONVEX LENS—74 mm. diam., 99 mm. F.L. Weighs 9 oz. Made of borosilicate Crown Optical Glass. Used as spotlight Lens, Condensing Lens, etc.
Stock No. 1048-Y ..... **$1.50 Postpaid**

BIG DOUBLE CONCAVE LENS—74 mm. diam., minus 110 mm. F.L. Made of extra dense Flint. Used as reducing Lens, for trick photography, etc.
Stock No. 1049-Y ..... **$1.00 Postpaid**

MISCELLANEOUS ITEMS

Stock No.	Item	Price
2024-Y	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm.—for making Filter)....	.25
523-Y	Six Threaded Metal Reticle Cells...	.25
624-Y	Neutral Ray Filter, size 4¾" x 2½"	.25
3022-Y	Round Wedge, 65 mm. Diam. Each.	5.00
3021-Y	Amici Roof Prism (3rd grade). Each	.25
16-Y	Level Vial, 48 mm. long.....	.20
1030-Y	2" Diam. Reducing Lens. Each.....	.25
1031-Y	Perfect 6 Power Magnifier, Diam. 28 mm.	.25

(Minimum Order on Above—$1.00)

PRISMS

Stock No.	Type	Base Width	Base Length	Price
3040-Y	Right Angle	33 mms.	23 mms.	$1.00
3045-Y	Right Angle	70 mms.	168 mms.	8.00
3001-Y	Lens Surface	20 mms.	14 mms.	2.00
3006-Y	Porro-Abbe	9 mms.	9 mms.	.25
3009-Y	Porro	52 mms.	25 mms.	1.00
3010-Y	Porro	43 mms.	21 mms.	.50
3016-Y	Pentagon	45 mms.	22 mms.	.75
3029-Y	Dove	16 mms.	65 mms.	1.25
3036-Y	80 Degree Roof	60 mms.	36 mms.	4.00
3047-Y	Right Angle	53 mms.	103 mms.	4.00
3038-Y	Roof Prism	18 mms.	34 mms.	2.50

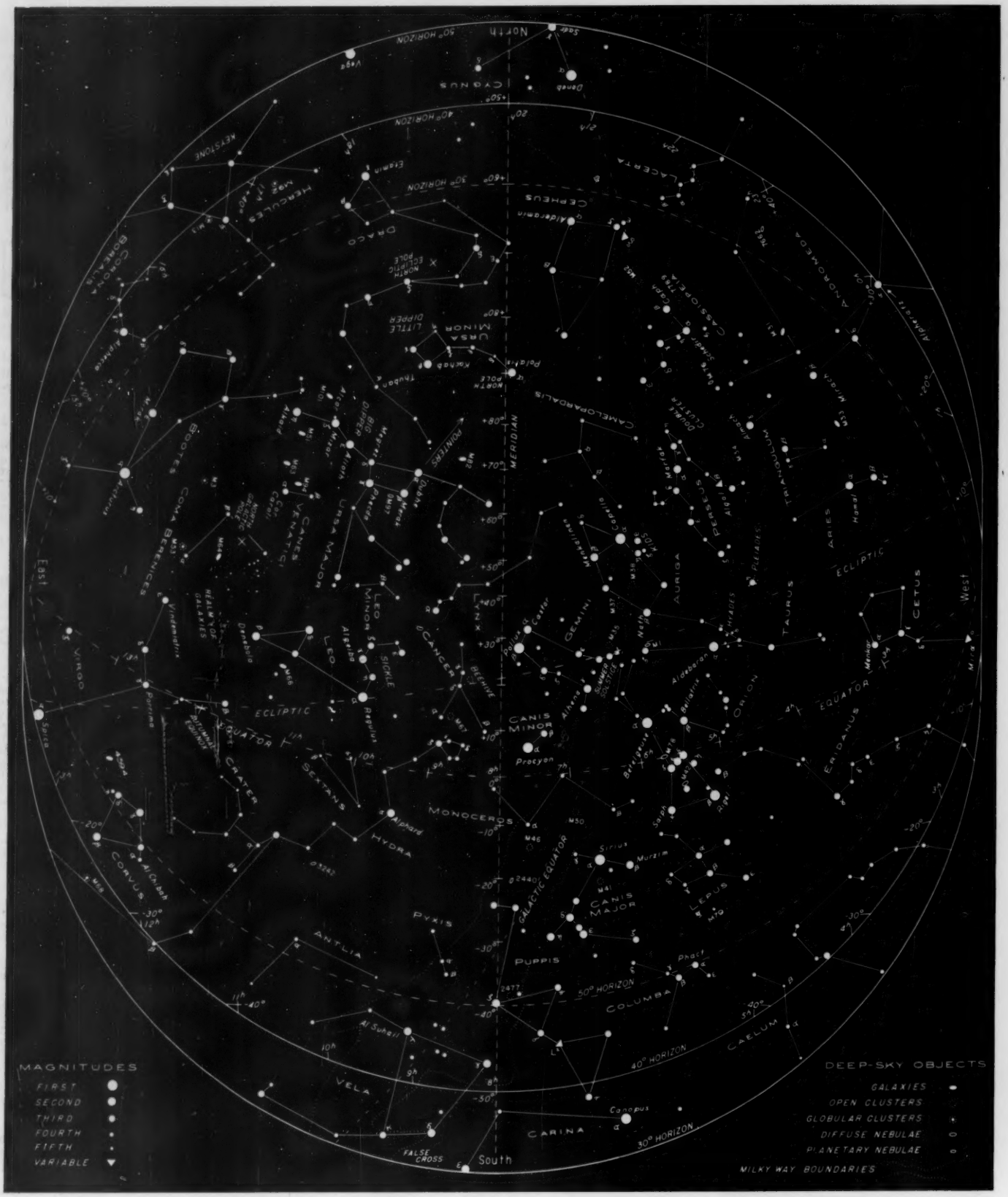
TANK PRISMS—PLAIN OR SILVERED
90-45-45 deg. 5¾" long, 2⅛" wide, finely ground and polished. Would normally retail from $24 to $30 each.
Stock #3100-Y Silvered Prism **$1.00 Postpaid**
Stock #3101-Y Plain Prism **$1.00 Postpaid**
Illustrated Book on Prisms included FREE.

TANK PERISCOPE

Complete Set Mounted Components
Rugged, strong, originally constructed for U. S. Tank Corps. Consists of 2 fine Periscope Mirrors mounted in metal and plastic. Perfect condition. Would normally retail at $40 to $50. **Stock No. 700-Y . . . $2.00 Complete Set Postpaid.**

ORDER BY SET OR STOCK NO. • SATISFACTION GUARANTEED • IMMEDIATE DELIVERY

EDMUND SALVAGE COMPANY + P. O. AUDUBON, NEW JERSEY



DEEP-SKY WONDERS

AMATEURS who look beyond the solar system are invited this month to hunt for the following. Many of these objects do not appear on the chart above. Norton designations are in parentheses.

Leo. NGC 2903, $9^h\ 29^m.3$, +21° 44′; spiral; oval, fuzzy, with a bright center. NGC 3521 (13′), $11^h\ 03^m.2$, +0° 14′; spiral.

Vela. NGC 3201, $10^h\ 15^m.3$, —46° 07′; globular.

Ursa Major. NGC 3556 (46^6), $11^h\ 08^m.7$, +55° 57′; spiral. Dim edge-on, between the Owl nebula (M97) and Beta.

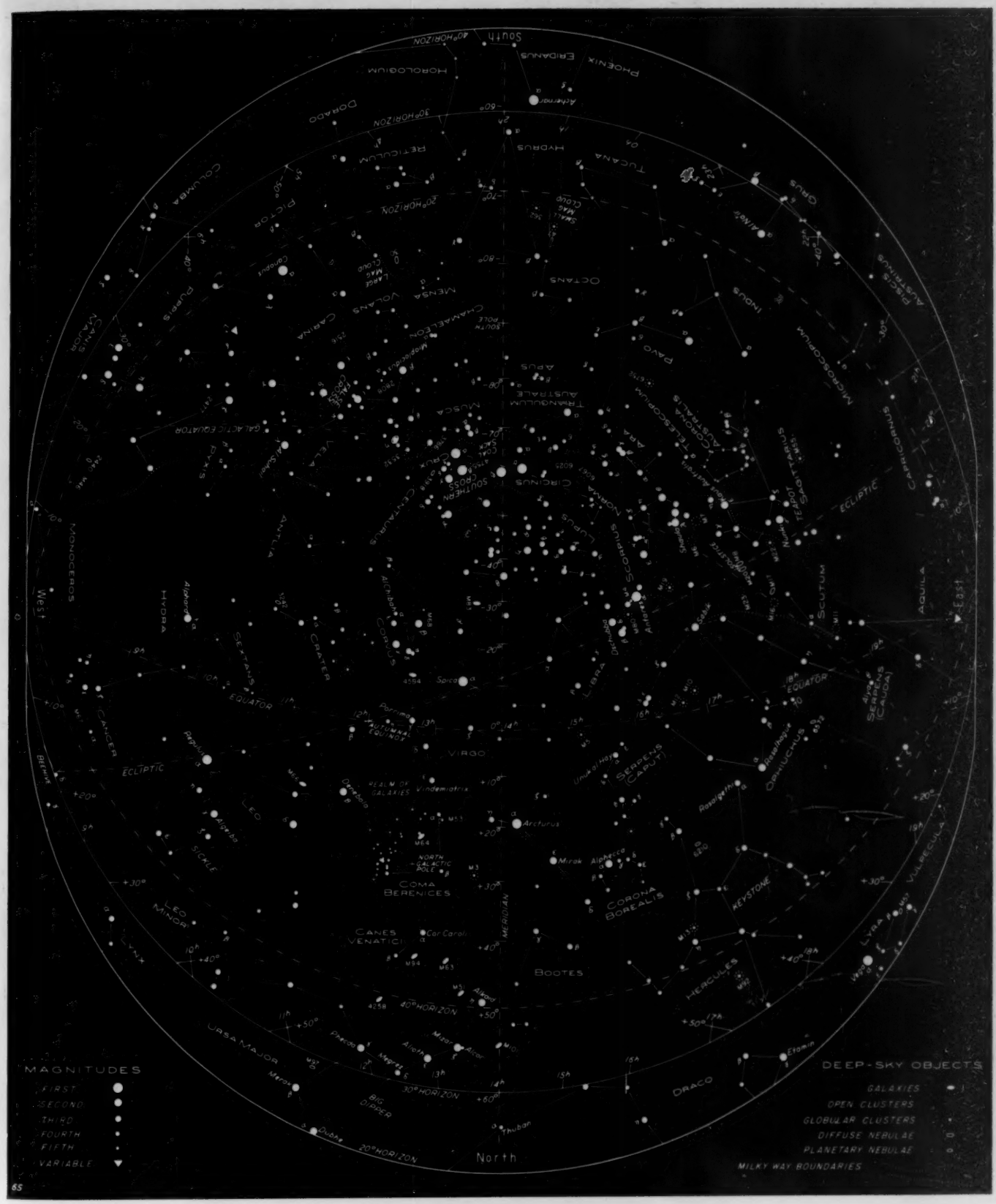
If you miss any of these, try M95 ($10^h\ 41^m.3$, +11° 58′) and M96, galaxies in Leo, and M67 ($8^h\ 45^m.8$, +12° 11′), a cluster of 67 stars in Cancer.

L. S. COPELAND

CHART CORRECTION: Bellatrix, in Orion, should be labeled Gamma, instead of Beta.

STARS FOR MARCH

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.



EVENING STARS FOR SOUTHERN OBSERVERS

THIS CHART is prepared for a basic latitude of 30° south, but it may be used conveniently by observers 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance, to allow time for transmission to observers in any part of the world. The sky is here shown as it appears on May 7th at 11 p.m., May 23rd at 10 p.m., June 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly, four minutes earlier per day. These are local mean times which must be corrected for standard time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts. For other charts in this series, see issues of alternate months, August, 1944, to June, 1945, and July, 1945 to the present.